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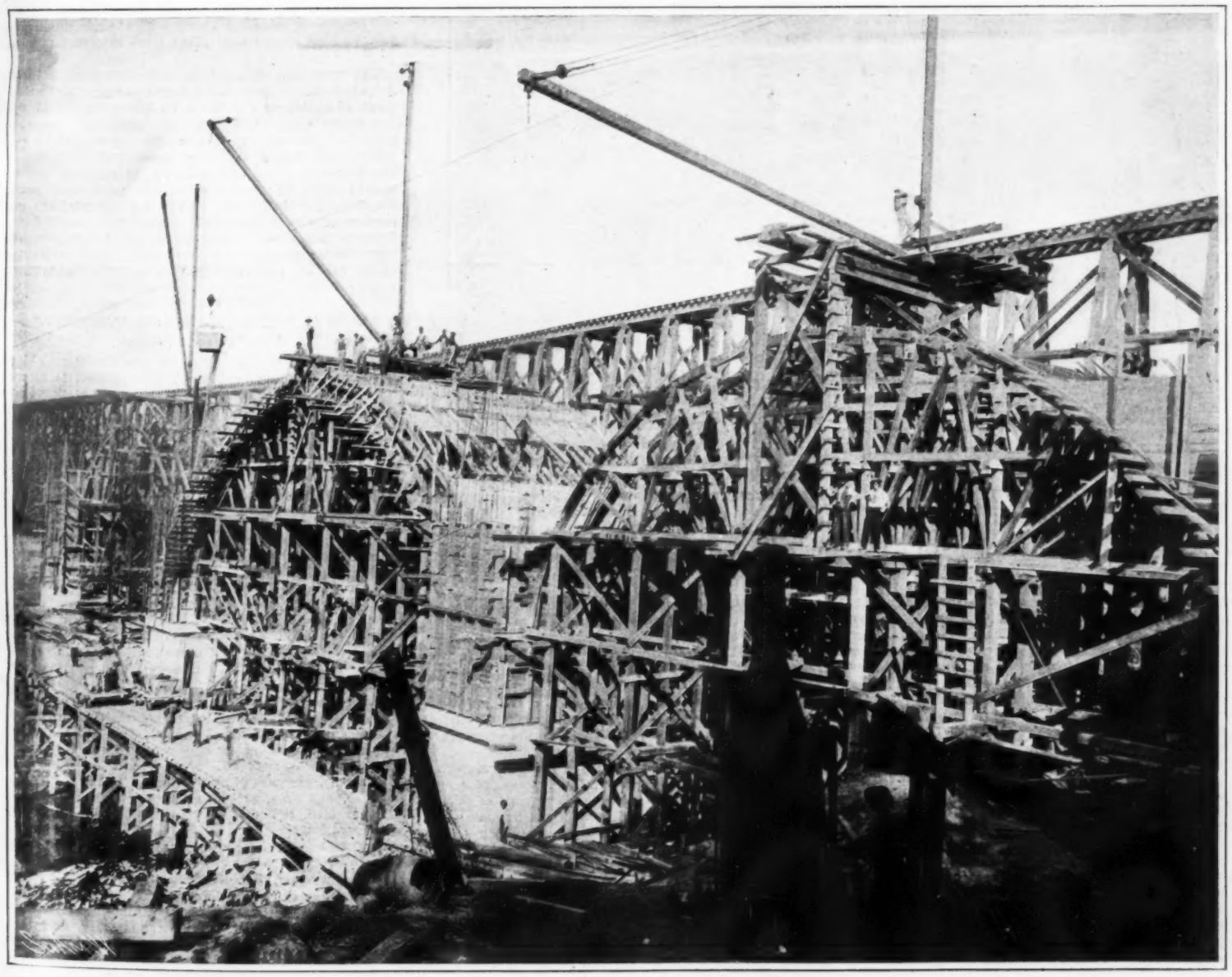
THE COMPLETED DANVILLE CONCRETE RAILROAD BRIDGE.



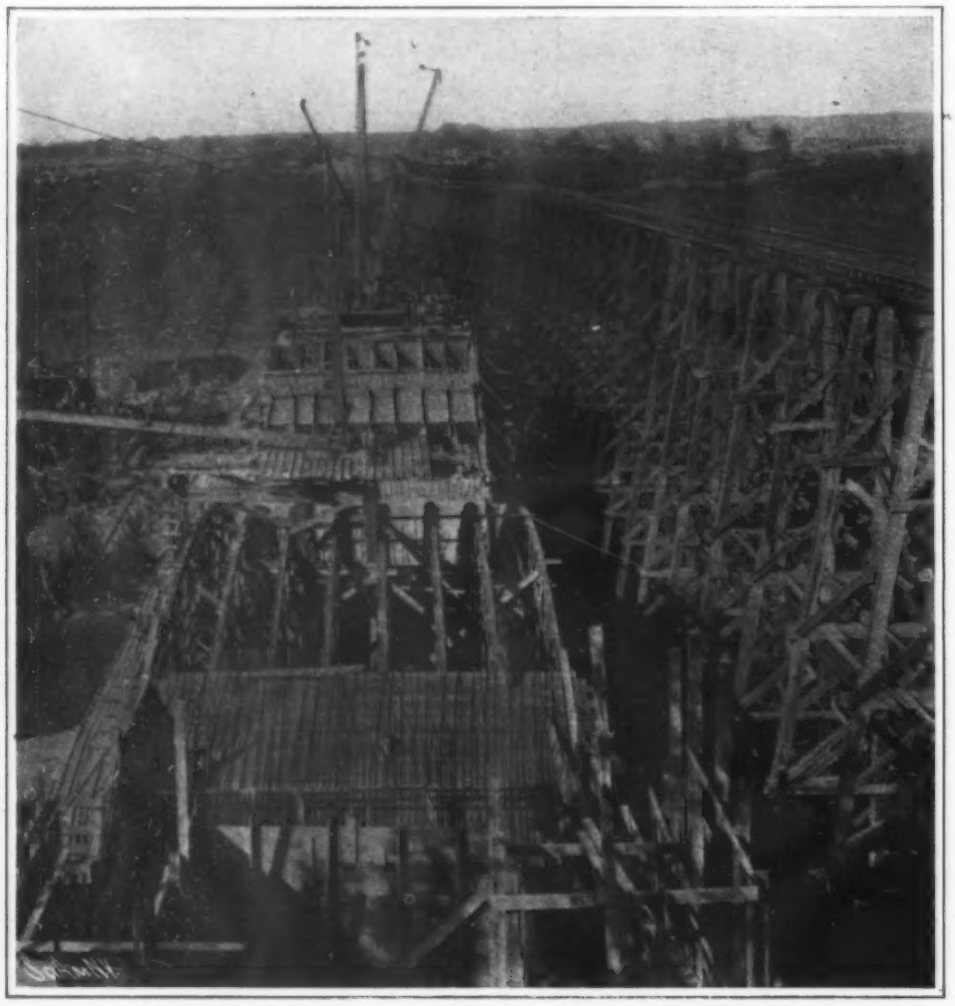
PUTTING UP THE FALSE WORK FOR THE MAIN ARCHES OF THE BRIDGE, SHOWING TEMPORARY TRESTLE IN THE REAR.

CONCRETE RAILROAD BRIDGE AT DANVILLE, ILL.

CONCRETE RAILROAD BRIDGE AT DANVILLE, ILLINOIS.*

The increasing utilization of reinforced concrete is nowhere more manifest than in railway construction work. A recent example of concrete bridge structures is found in the Danville arch bridge of the Cleveland, Cincinnati, Chicago and St. Louis Railway, at Danville, Ill., which is not only of considerable size, but is of rather unusual design as well. The bridge is part of the complete reconstruction of the Cairo division which, together with other improvements, forms a direct connection between the coal fields of Indiana and Illinois and Chicago. The valley of the Salt Fork of the Vermilion River which the line crosses is about half a mile wide and from sixty-five to ninety feet below the grade of the tracks, the north side being on a steep slope. The Salt Fork flows adjacent to the south side of the valley, which is formed by a line of precipitous bluffs some 130 feet above the bed of the stream. The bridge crosses the Salt Fork with one end abutting against this steep bank, while the remainder of the valley is traversed by means of a fill 60 to 80 feet high and of sufficient width to carry two tracks.

The bridge comprises three arches, one of 100 feet span in the middle, and two of 80 feet span at each end of the structure. There are two channel piers which carry the central arch, each of which supports one end of an 80-foot arch as well. The outside ends of the smaller arches are carried by the bridge abutments.



FALSE WORK AND LAGGING FOR THE MAIN ARCHES UNDER CONSTRUCTION.

CONCRETE RAILROAD BRIDGE AT DANVILLE, ILL.

The 100-foot arch has a rise of 40 feet, while the smaller arches have rises 10 feet less. The difference of the rises is equalized by a corresponding difference in the height of the springing lines above the bed of the stream, that of the central arch being 26 feet. The rails are located at a height of nearly 20 feet above the extrados of the crown of the arches, and the tracks rest directly on a five-foot earth cushion carried by the bridge. Series of transverse arches about 2 feet thick at the crowns, and having spans of 8 feet, are carried by the main arches. Usually between the bottom of the earth fill and the extrados of the main arches are longitudinal spandrel walls with the filling between. In this case these are replaced by the series of transverse arches, the crowns of which are in the same horizontal plane and carry a longitudinal coping between which is located the earth filling.

The entire structure above the springing lines is reinforced by means of a corrugated bar system in the usual manner. The series of transverse spandrel arches is built in three sections, one over each main arch ring, and the arches in each section are tied together by reinforcements, while expansion joints separate the sections one from the other. At all the joints, the concrete is worked in as smooth and flat as possible, so that the contact between the adjacent faces of the joints is made only through the rails embedded in those faces, which are separated by layers of felt carried nearly to the top of the joints, the remaining space at the top being filled with asphalt.

The channel piers above the arch rings of the main arches are hollow, each of the sides being formed by one of the bench walls, the top of which carries an expansion joint. The ends are each formed by pilasters carried up from the springing line of the large arch, and formed of reinforced concrete slabs nearly 60 feet long placed on the end.

The footings of the channel piers are carried down ten feet into the shale formation of which the bridge is built, while that of the north abutment is carried down four feet. The south abutment is built on the steep bank of the valley with its top about 12 feet below the springing line of the south arch. The back portion of this footing rests thirty-six feet below the natural surface on a limestone bed rock, while the front half is six feet above the rock, as the thrust from the arch reduces the load on that portion.

As soon as the footings of the piers and abutments were completed, the construction was carried up to the springing line of the three main arches, while at the same time the false work and centering for the center arch were being erected. The false work for each of the three arches comprised six transverse bents, which were carried up in 22-foot stories with caps at each story. The wooden structures were thoroughly swaybraced at short intervals by means of horizontal timbers and were cross-braced transversely as well. They were carried on plumb posts placed on piles driven four feet into the shale. The plumb posts and struts were bolted at the top of the ribs, but were not attached to the false work and were only braced against each other near their lower ends. The arch ribs were formed of 12-inch planks, 2 inches thick, bolted together on the ground in sections and hoisted into place by derricks.

The reinforcing of the main arches, as well as of the structure, is very thorough. The longitudinal ribs of the main arches comprised 33-foot lengths of one-inch bar overlapped four feet at the ends and spaced 12 inches apart. The arch rings are further reinforced near the intrados with similar longitudinal ribs conforming to the curve of the arch. The ends of all the ribs are anchored in the masonry of the haunches and the reinforcements are so arranged that each of the three main arch rings is practically a monolith. The pilasters of the channel piers, mentioned above, extend to a five-foot coping at the top of the bridge. The pilasters are reinforced vertically and longitudinally by corrugated bars and are anchored at the top by horizontal transverse rods extending from the slabs over the bench walls. The inner face of each pilaster bears against the end of the two bench walls over the main pier and the end of the slab above the latter, but is entirely separated from all three by sliding joints. The bench walls are 2 feet thick and are 10 to 21 feet high. They are reinforced near their faces by vertical bars spaced 12 inches apart which overlap at the base of the wall with bars which extend into the main arch ring and are anchored by bending. The bars in each wall, at the same time, extend over the haunches of the adjacent arches. The reinforcement bars in the bottom of the wall also extend into the concrete of the arch rings and were placed in position as the latter were concreted.

Difficulty was encountered in the work because of the rough nature of the neighboring country, which almost excluded the possibility of using teams for hauling material. However, a high timber trestle, used for making the fill beyond the bridge, was erected below the bridge structure and curved into the line of the tracks for the new road beyond the north end of the bridge. This was employed for the transportation of the material, but its use was attended with the drawback that there was practically no space for the storing of material, and consequently, it was necessary to construct a spur a mile long for delivery purposes. The concrete mixing plant was so located that it could handle material from the cars on the track or from along the river side of the latter. The 12,000 cubic yards of concrete necessary to complete the structure were made by a Smith mixer set on a platform about seven feet above the ground and located underneath a hopper and connected with a second hopper, for storage purposes. A clamshell bucket on a guide derrick handled the material to the mixer. The latter discharged into buckets on push cars running on a temporary track laid under the platform.

Dressed plank 2 inches thick and from 8 to 10 inches wide, together with timbers of varying sizes for posts, constituted the lagging for the forms of the piers, pilasters, abutments and the bench walls. The lagging for the main arches was of heavier planking and timbers, while that for the spandrel arches was 1 x 3-inch matched flooring. All the pairs of vertical forms were tied together with wires and well braced to hold them in position.

The concrete in the 100-foot arch ring, which was divided into eleven sections, was laid as soon as the blocks over the tops of the two piers were in place. The latter up to the springing lines of the 80-foot spans, which were divided into nine transverse sections, were laid first after the false work and centering had been completed. The south 80-foot arch was built after the 100-foot arch was completed, and the north end arch was finished after that. The transverse sections of the arch rings were laid in successive order, beginning at one end for the middle arch and varying the succession in the end arch. The longitudinal reinforcing bars of the arch rings were always lapped as near the middle of the sections as possible.

The work of concreting the structure was begun on August 8 of last year, but owing to delays in the shipment of materials the work on the main arches was not begun until October 4. The structure was completed by December 17, the work being carried on constantly in ten-hour shifts. A good idea of the size of the bridge is given by the figures of some of the materials used; for instance, 260,000 pounds of corrugated bars, 5,000,000 feet of lumber, the total exposed surface of which was 92,000 square feet, and 700 carloads of materials. It can be seen that it was a difficult matter to handle this material with a storage space capable only of handling eight carloads at a time.

*Specially prepared for the Scientific American Supplement.

THE PROBLEM OF SMOKE ABATEMENT.*

By William H. Bryan.

Attempts at smoke abatement are almost as old as the art of burning fuel itself. The subject is almost as attractive to the average inventor as is perpetual motion. To the engineer who works in this field will come many experiences, some pleasant and some unpleasant, but all interesting.

First of all, there is the cheerful crank, whose furnace consumes everything by passing the gaseous products of combustion back underneath the grates. Devices without number of this character have been seriously proposed. It is needless to say, however, that none have been successful. Even those which have been tolerated temporarily have found it necessary to discharge some gases and admit some fresh air.

Then there is the man who sprinkles the smoke with a jet of water—in other words, launders it. Another school mixes with the smoke so large a surplus of air or steam, or both combined, as to practically drown the smoke out, or dilute it to harmless proportions. The effect on the coal bill can be imagined. Other inventors have processes by which they extract from the waste gases by-products of fabulous value.

The trouble is that few inventors realize the complications and difficulties of the problem. The average steam boiler is subject to wide variations in its output, and is often overworked. More often the setting is in bad repair, and was of poor design originally, in grate surface, gas area, and flue and chimney dimensions. Oftener still, the poorest grade of unskilled labor is employed. When, in addition, such a furnace is required to handle the poorest grades of fuel, it is hopeless to attempt to control the smoke.

Not every man, however, is willing to do his share toward reducing the smoke cloud. First, and most important, is often the manufacturer himself. His argument is that a smoky city is a busy city, and that restricting smoke means interference with his business affairs, restricting and hampering his output. He tells us that a smoky but busy city is preferable to a dead

* Lecture delivered before the students of Purdue University.

town with a clear atmosphere. His argument falls to the ground when we remember that a smokeless chimney is not inconsistent with severe and continuous boiler service.

Other objectors are those who have made attempts—more or less earnest and intelligent—to stop the smoke, but have failed. In most cases the attempt has been only half-hearted, but in others much money has been spent in misdirected effort. Many such people believe that the smoke cannot be stopped, and that it is useless to try.

What is smoke, anyway, and what causes it?

The constituents of all fuels may be classified as volatile matter, fixed carbon, and ash. The ash is inert as regards smoke except that when present in large quantities, it impedes the proper handling of the fires, necessitating frequent cleaning, which is always detrimental. The fixed carbon, with which we are familiar in the form of coke, is smokeless. The remaining constituent, the volatile matter, occurs in large percentages in our western fuels, and to it the smoke is due.

When a fuel rich in volatile matter is charged into a furnace, the volatile matter is first set free as a gas, principally in the shape of hydro-carbons. Part of these are of the olefiant series, and are dissociated at a red heat. Part of the carbon is set free, and, if unconsumed, it passes off as smoke. It is possible to burn this free carbon, if sufficient oxygen is present, and the temperature is high. Failing in either of these conditions there will be a smoke.

The free carbon in the densest smoke is very small, from one-sixth to one-half of 1 per cent by weight. It has, however, great coloring power. You may stamp as false all claims of fuel saving due to consuming the smoke. The best furnaces, however, do make savings in fuel, not because they burn the smoke, but because improved construction and better engineering details bring about more favorable furnace conditions. The saving is often more than sufficient to pay a good interest on their cost, besides repairs and maintenance.

Broadly speaking, there are three methods of reducing smoke: First, the closing down of smoke-making plants; second, the use of smokeless fuels; third, the burning of ordinary fuels smokelessly.

Heroic as it may seem, much good has been accomplished by the actual shutting down of plants. A few years ago all large cities were dotted with small factories, each with its smoke-making boiler. To-day such plants are operated by electric motors, supplied with power from central stations located at a distance and provided with smoke-preventing apparatus. Many buildings get their entire service of light and power from the street mains, operating their boilers only during the cold months for heating. This practice may be expected to grow as electricity becomes cheaper, and is distributed over wider areas.

Much has been done in smokeless fuels, particularly for heating in the residence districts, and for many special operations. It is not too much to ask of the average good citizen that he will, if necessary, go to some expense to aid in beautifying his city. This, however, could not be expected under steam boilers, which are the largest smoke producers. It was hoped that oil from the Texas fields could be introduced at something like reasonable cost, but present rates are prohibitive. Oil has many advantages, however, which would justify a considerable increase in cost over coal. In addition to solving the smoke problem it greatly reduces the labor charge, can be handled and controlled more easily and usually permits an increase in the working capacity of the plant. On the other hand, however, the elements of danger and of odor are ever present. As indicating in a general way what may be done under boilers with the various fuels coming to the St. Louis market I prepared a table some time ago, based on St. Louis prices ruling before the recent advances. No claim is made for the absolute accuracy of the figures, but they are believed to be fairly reliable—relatively, at least. A glance is sufficient to show that the smokeless fuels are out of reach in cost, except possibly as the use of powdered coal may be developed.

Fuel.	Cost, Dollars.	Calorific Value Heat Units.	Efficiency, Per cent.	Equivalent Evaporation in Lbs. of Water.	Cost of Evaporating 100 Lbs. of Water.
Fuel gas..	Per 1000 Cu. Ft. 0.10	Per 1000 Cu. Ft. 240,000	80	Per 1000 Cu. Pt. 198.8	Cents. 50 30
	Per ton of 2000 Lbs.	Per Lb.		Per Lb.	
Anthracite.....	6.75	14,000	75	10.87	31.08
Texas oil.....	8.08	15,960	80	13.22	30.56
Coke.....	4.50	12,500	70	9 05	24.87
Pocahontas	4.75	13,300	72	9 90	24 00
Big Muddy	2.50	12,200	68	8.57	14 60
Mt. Olive, lump ..	1.60	11,200	65	7.55	10.62
Powdered coal....	1.25	10.000	80	8.28	7 55
Common slack....	0.90	10,000	60	6.20	7.25

The deliveries in this table are assumed to be on cars at consumer's switch. The oil weighs 7.43 pounds per gallon, and at the same time cost 3 cents per gallon, 2½ cents of which was freight. This price has since been raised, but even at these figures it falls short of competing with coal, even after adding 40 to 50 cents per ton for handling the coal and ashes. The outlook for oil would be better if, instead of burning it under boilers, it be used in oil engines of the Diesel or other modern type, which consume about ¾ pound of oil per I. H. P. hour. The ordinary Corliss engine uses about 4 pounds of Mount Olive coal per I. H. P. hour. At these figures the fuel cost would be practically the same for oil as for coal.

In the table it is assumed that the powdered coal is made from ordinary slack, at an additional cost of 35 cents per ton for powdering. This charge will be offset by the saving in labor for coal and ash handling.

After all, however, our greatest hope for relief lies in burning ordinary fuels smokelessly. As the worst offenders are the steam boilers, they only will be discussed. Devices without number have been invented for this purpose, but, unfortunately, most of them have failed to meet the exacting requirements of regular service.

It should be remembered that a good ordinary boiler furnace without a special device can be so handled as to greatly reduce the smoke, provided, of course, it is not overworked. It is not necessary, therefore, to buy somebody's patent furnace. Nor will the installation of improved apparatus of itself control the smoke. A deep furnace, high bridge wall, ample grate surface and good draft are essential to a good smoke record. Such a furnace, skillfully fired, will make no serious smoke when working up to, say, two-thirds of its rated capacity. By skillful firing is meant the charging of alternate doors with small and uniform quantities of fuel, particularly if the coking system of firing is used. The firing of consecutive doors, at long intervals, with large quantities of fuel, and by the sprinkling method, is responsible for a very large proportion of our smoke.

If the furnace, however, is not well designed, or is overworked, no amount of skill or care will keep the smoke within bounds. In such cases resort must be had to special apparatus. Successful processes may be divided into five classes:

First, Steam Jets.—These are the simplest devices in use, and can be put together by any engineer at small expense. Sometimes they are placed under the grates, discharging into the ash pit, but more often they are above the grate, immediately over the fire doors or in the side walls, discharging backward or across and slightly downward. The jet draws in air and discharges it at high velocity immediately above the fire, where it meets the gases being given off by the disintegrating fuel.

Devices of this character have come into extensive use. They are reasonably effective in reducing smoke, but are not usually economical in fuel. The jets are often allowed to blow continuously, but it is better to turn them on at the time of firing and then shut them off in two or three minutes, after the fresh fuel has been ignited. In some devices this is done automatically, the act of opening the fire door turning on the jet admitting steam and air, and clockwork or dashpot mechanism gradually closing it.

Second, Coking Furnaces or Firebrick Arches.—These come next in first cost, and are capable of giving almost perfect results in smoke abatement if properly designed and intelligently operated. The fire-box is kept well away from the cooling effect of the heating surface, and can therefore be maintained at high temperature. Contracted checker work, or throat areas, insure a thorough mixture of air, which is often preheated. These are built in many forms, many of which are capable of burning very inferior fuels. They are excellently adapted to plants where the service is reasonably uniform. The objections are that some forms require an increase of space, and the brickwork, if not properly constructed, may not be durable and repairs may be large. These objections, however, have been very largely remedied in the best types. There will usually be a material saving of fuel over the common setting if properly constructed and operated.

Third, Down-Draft Furnaces.—These have proved very successful in many instances, and have come into extensive use, particularly where excessive demands for overwork are frequently made.

In the Hawley, one of the best known forms, there are two grates, one above the other. The upper grate is a row of water tubes, single or staggered, so connected as to form part of the circulation system of the boiler. Grates of the ordinary pattern would not withstand the high temperatures. The tubes are inclined upward to the rear to insure rapid circulation. The space above the rear drum is closed off, and the gases must make their exit downward through the bed of fuel. Considerable partly burned fuel falls to the lower grate, where its combustion is completed under very favorable conditions. The two flames unite at the rear of the grates, forming a throat through which it is almost impossible for the particles of free carbon to pass unconsumed. Somewhat greater draft is usually required for this furnace than for the common setting. Most of the air required for combustion enters through the doors above the upper grate, a small amount being admitted under the lower grate. The furnace is independent of the skill or ignorance of the fireman to greater degree than many others. The objections are its first cost, and the fact that it is part of the present system of the boiler. With bad water or careless or insufficient handling, there is great liability to tube and drum repairs. It usually effects a considerable saving in fuel.

Fourth, Automatic Stokers, with which may be classed chain grates and underfeed devices. These have come into extensive use, particularly in large modern plants. While they are built in many forms, they all operate on the same principle—that of feeding the coal automatically to the grates in continuous and regular amounts. Most of them are designed for the use of the finer grades of coal, such as nut, pea, or slack. In many localities there is a surplus of this fuel, and its cost is low, but the increasing demand is raising the price and reducing the supply. Many recent stoker plants are provided with crushers to permit the use of the larger sizes of coal when necessary. When accompanied by coal handling and storage plants the automatic stoker reduces the labor required in the fireroom, and this arrangement has been adopted in many large modern plants. The ability of the stoker to maintain practically uniform steam pressure, and the fact that the air supply is nearer theoretical requirements, are features which have contributed largely to its success.

The objections to automatic stokers are: First, their great cost; second, the complication of parts and the necessity of repairs; third, the steam required to operate them. Under proper conditions there is a material saving both in fuel and labor. That the objections named are not serious is shown by the fact that their use is constantly increasing. The fuel to be burned should have expert study, however, before a device of this kind is selected, as they are not equally well adapted to all fuels. Some do not respond to fluctuating loads, and to overwork, as well as other types of furnaces.

Fifth, Powdered Fuels.—These have recently attracted much attention, having for years been employed successfully in rotary cement kilns, and more recently under boilers to a limited extent. Experiments along this line have been under way for some time in European countries with considerable success. In the most satisfactory devices the coal is reduced to an almost impalpable powder, and is then forced into the furnace under pressure, exactly as would be done with oil or gas. Among the greatest advantages of this fuel is the fact that it may be made of slack or mine waste, which can be had at very low cost. While the apparatus for burning fuel is simple and inexpensive, the plant necessary for preparing the fuel is somewhat elaborate. As the fuel is explosive and liable to spontaneous combustion, it cannot be stored or handled in quantities, but should be used as fast as made. This would seem to call for a powdering plant at each point of use. There is reason for hoping, nevertheless, that good results may be looked for in the not distant future.

Space will not permit a discussion of all the methods which have been proposed, but the foregoing covers in a general way the devices which have been more or less successful. The list would not be complete, however, without mentioning double combustion furnaces, and mechanical draft, which has come into limited use with encouraging results, both alone and in combination with others of the above named types.

The classifications enumerated above are not always clear and distinct, as the types named are often found in combination. The fire-brick arch, for instance, is nearly always found in combination with the stoker, and often with the steam jet.

The fireboxes of locomotives and of steamboats require special treatment, but brick arches and steam and air jets have given good results. The best work is done when the two are combined. Some experiments have also been made with downdraft furnaces, with promise of success. Oil is admirably adapted for locomotives and is already in extensive use where the cost will permit. It is urgently recommended that large grate and heating surface be provided wherever possible.

I am unhesitatingly of the opinion that at least one—usually more—of these devices is applicable successfully to every smoke-making boiler, and that, too, without hardship. Great care, however, must be exercised; first, in selecting the apparatus, to insure that it is properly adapted to the service, second, in seeing that it is carefully applied, so as to be reliable and durable, and, third, that it is intelligently operated and maintained. The last is perhaps the most important of the three. No apparatus, however efficient, can be expected to run itself. Give it a chance; see that it is taken care of and kept in repair, and not abused.

Incidentally the smoke-abatement movement has led to a closer study of boiler conditions, with the result that the modern boiler room, in arrangement, lighting, ventilation, and general efficiency, is a creditable piece of engineering. It is entitled to be given at least as much attention, both by the designing and the operating engineer, as any other part of the plant. Hardly less important is the proper care and management of the boilers, and particularly of the fire itself. A good fireman should be encouraged. It pays to keep a good man, even at an advance in salary, for his hand is in the owner's pocket all the time.

The following directions regarding intelligent methods of firing with a view of securing efficient and smokeless performance may be of interest:

Fire frequently and in small quantities. Break up the lumps to the size of a man's fist. Carry a level fire over the entire grate surface, not too thick. Avoid thin or bare spots. Keep the fires clean.

Fire one door at a time, and wait until that fire is in good shape before charging the other door. Keep the time intervals between firings as nearly uniform as possible.

Fire not over three shovelfuls per door to begin with. If this makes no serious smoke, increase to four shovelfuls, and then to five or six shovelfuls until the smoke from the chimney shows that the limit has been reached.

Immediately after each firing leave the fire door slightly ajar for three or four minutes, thus admitting a little fresh air above the bed of fuel.

Our sympathy goes out to that individual who complained in a newspaper recently that the soot from the

smoke so soiled the snow that he could not play snowball, as in childhood's happy days. Nor can we answer that individual who expects the smoke department to do away with our river fogs. More interesting but even less tractable, is our friend who, when the banquet is over and cigars lighted, dares us to do our worst in preventing smoke.

Seriously, however, it is not a losing fight. Most cities now have strict ordinances controlling the smoke question, and more or less effort is being made toward their enforcement. As a rule, the courts are sustaining these laws. Some eastern cities, among them New York and Washington, prohibit the use of soft coal altogether, and I am informed that it is an offense in New York to even have it on the premises. More good, however, is done by moral suasion than by legal procedure, appealing to the civic pride of the average good citizen, and pointing out that the best methods insure a fuel economy amply justifying the original outlay.

Mishaps and discouragements are not unknown in the work, but the appeal to good citizenship, the education of the public, and—more than all—keeping everlastingly at it, will surely bring relief to any smoke-encompassed town.

ALCOHOL AS A FUEL.

The passage of the "denatured" alcohol bill is likely to have a somewhat important effect upon power production upon a small scale. The fact is that alcohol, in spite of a thermal value more than 30 per cent below that of gasoline, has still some practical advantages of a very valuable character. During the many hearings upon the bill much important information was elicited. It seems to be generally agreed that in an engine of given cylinder dimensions and speed alcohol, when properly used, will produce a greater output than gasoline—in the opinion of one of our best-known engine builders, to the extent of some 20 per cent. The gain is mainly due to the greater compression at which it is possible to work the alcohol without producing auto-ignition, hence the greater the expansive action obtained, the lower the temperature of the rejected gases and the higher the thermal efficiency. It is understood that with a proper engine the thermal efficiency may be raised to and above 30 per cent, while with gasoline the efficiency would be nearly 10 per cent lower. In point of safety, too, the alcohol has a very considerable advantage in that it has a very much lower flashing point than any petroleum product that can be readily worked in an internal combustion engine. Of course, even crude petroleum can be so used if necessary, but far less easily than the hydrocarbons of lower boiling point.

Alcohol, too, burns with a pale-blue flame that radiates little heat and produces no soot. Its heat is delivered mainly by convection as in the case of a Bunsen burner, so that the danger of overheating objects near the flame but not above it is really lessened; and an alcohol fire can be put out with water, which a gasoline flame resists, since the fuel floats on water instead of mixing with it. More than this, alcohol has an odor at least inoffensive, while gasoline has an effluvium which Coleridge in enumerating "the two and seventy stenches, besides several stinks," of Cologne, would have placed quite in a class by itself. So much for alcohol in the open air or in storage. In engines it works admirably, giving very clean combustion, of which the main product is water vapor. Less easily vaporized than gasoline it still is readily enough managed, and as we have seen, gives excellent efficiency. As to actual costs in operating alcohol engines, data differ somewhat. A few engines have been sent from this country to Cuba, where they are worked on alcohol costing 10 to 12 cents per gallon for a spirit quite good enough for the purpose. At this price gasoline would be at rather a disadvantage assuming equal dynamical value per gallon. Prior to the passage of the recent bill such spirit would have carried a prohibitive tax, some $4 per gallon. Even now it will have to carry some extra charge for denaturizing. Wood spirit, much used for this purpose, is much more expensive than the alcohol itself, and pyridine, the other substance considerably used for "denaturizing," is far from cheap and has a most infamous odor.

Evidently there is room for improvement in the process of denaturization, and the time before the bill goes into effect can be utilized to good purpose in working over the problem. Even using wood spirit for the purpose still leaves a fair margin of cost in favor of alcohol when the manufacture gets fairly under way. All sorts of vegetable waste, such as refuse from the beet sugar process, can be utilized for alcohol making, as well as surplus grain in times of exceptional crops. To take full advantage of all this the denaturizing process must be simple, cheap, and effective, and watch should be kept lest some of the chief gains of the bill be nullified by regulation for denaturization, such as would practically throw the industry into the hands of a monopoly. Given the spirit at anything like the price claimed by its advocates, and we would seem to have a fuel peculiarly well adapted for many cases of small power production, for subsidiary heating purposes so important in many industries, and for auxiliary residence heating. To make the best use of it in explosion engines, special machines will have to be produced, although foreign experience shows that the same engine can use either alcohol or gasoline without so great losses as have sometimes been alleged. One large German maker gives the difference in weight of fuel as about 10 per cent in favor of gasoline in an engine adapted for the use of either. However, the special engine is the proper thing to use for high economy, and it will come along quickly enough when there is a demand for it. It would seem, too, that it should be easier to make a successful two-cycle engine for alcohol than for gasoline on account of the cleaner combustion. It is hardly to be expected that alcohol can be used economically for power production on any large scale, producer gas being too severe a competitor. The real gain in using alcohol is ultimately in the fact that one is employing a material which can be reproduced in the cycle of the seasons instead of drawing upon the stored energy that is so rapidly being depleted.—Electrical World.

A NEW DUPLEX FOUR-CYCLE GASOLINE MOTOR.

By the Paris Correspondent of Scientific American.

The Boudreaux-Verdet motor, which has lately been placed on the market in Paris, is of somewhat novel design. It is intended to obtain the advantages of a two-cylinder or a four-cylinder motor, while at the same time the number of parts is much less. The simplest form of the motor is the duplex, and by combining two of these, a bi-duplex or quadruplex motor is obtained.

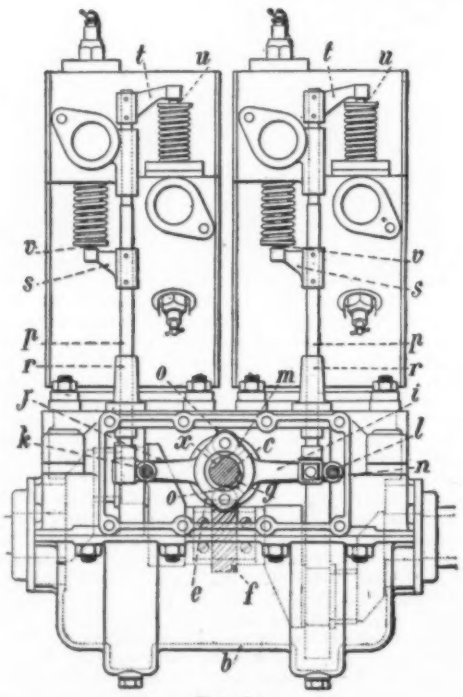


Fig. 2.

c, Transverse half-speed cam shaft; d, plate carrying lever arms; e, f, spiral driving gears; x, g, depressed and raised cams for operating lever arms; i, j, lever arms pivoted at l and k; o, o, rollers of lever arms; p, q, valve-operating rods moved by lever arms; s, t, brackets on valve-operating rods.

In the duplex motor we have a piston which is made double, as will be noticed in the section. The upper part of the piston has a smaller diameter and works in the top cylinder, *A*, while the lower part is enlarged to form a second piston, working in a second cylinder of larger diameter, *B*. The two cylinder chambers are so proportioned as to have an equivalent capacity. Thus we find a single piston moving in two distinct chambers and the effect of the explosion is transmitted to the crankshaft of the motor by a single connecting rod and a single crank. The explosions of the two cylinders are successive, like those of an ordinary two-cylinder four-cycle motor, but they are distanced equally. The upper cylinder of the duplex motor works like the ordinary form of cylinder, while the lower one is made to operate practically and give an efficiency equal to that of the upper one by means of a pair of explosion chambers formed in the outer casting and containing the spark plugs as shown in Fig. 4. In the lower cylinder, when the piston arrives at the end of the stroke, its upper end reaches almost to the top of the cylinder, and the gas is practically all compressed in the outer explosion chambers. The lower cylinder thus serves only for the expansion of the gas due to the explosion. Care is taken to design the form of the explosion chambers so that the speed of ignition is rendered high, due to the compact form of the chamber which brings all the gas near the spark plug. The ignited gas does not surround the part of the piston which has the smaller diameter until the piston is moving downward, owing to this disposition, and this part is thus prevented from heating to an abnormal degree by coming in contact with the burning gases when they are hottest.

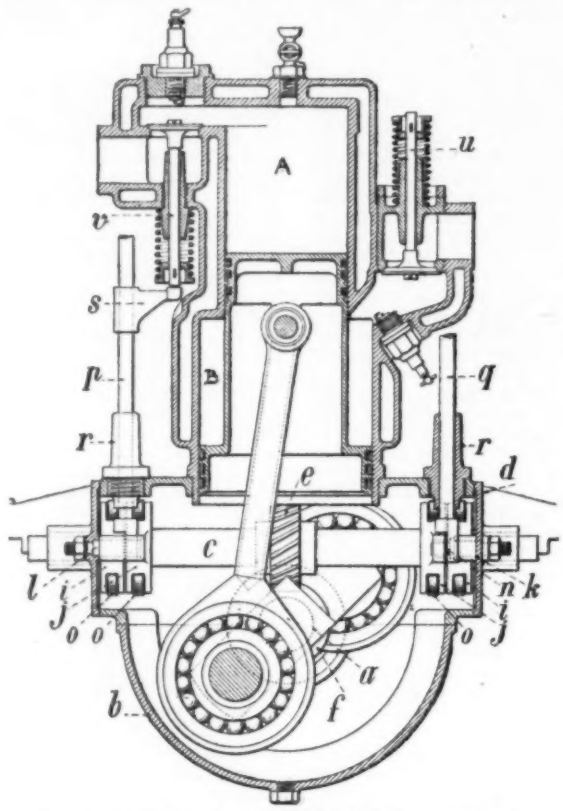


Fig. 1.—VERTICAL SECTION OF ONE OF THE CYLINDERS.

c, Transverse half-speed cam shaft; d, plate carrying lever arms; e, f, spiral gears for driving cam shaft; i, j, lever arms for operating valves; o, o, rollers of lever arms; p, q, valve-operating rods; s, t, brackets for operating valves.

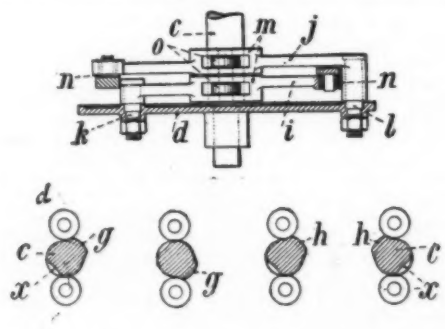


Fig. 3.—PLAN VIEW OF LEVER ARMS AND DIAGRAM SHOWING ARRANGEMENT OF FOUR DOUBLE CAMS.

c, Cam shaft; d, supporting plate of cam shaft; i, j, lever arms; k, l, pivots of lever arms; m, annular part of lever arms carrying rollers; n, vertical push rods resting on lever arms; o, upper rollers of lever arms.

On the above principle a double or bi-duplex motor may be formed by placing two such motors side by side The two piston rods are connected to a common crankshaft by two cranks situated at 180 deg. In this way we secure on the four-cycle principle the advantages of a 4-cylinder 4-cycle motor, but only use two

pistons, rods, and cranks instead of four. The question of the crankshaft bearings is much simplified, since five bearings are generally used in the four-cylinder motor, while in the bi-duplex there are only two of these.

Further simplicity is secured by the method of operating the eight valves of the motor. These valves are placed symmetrically in ignition chambers on each

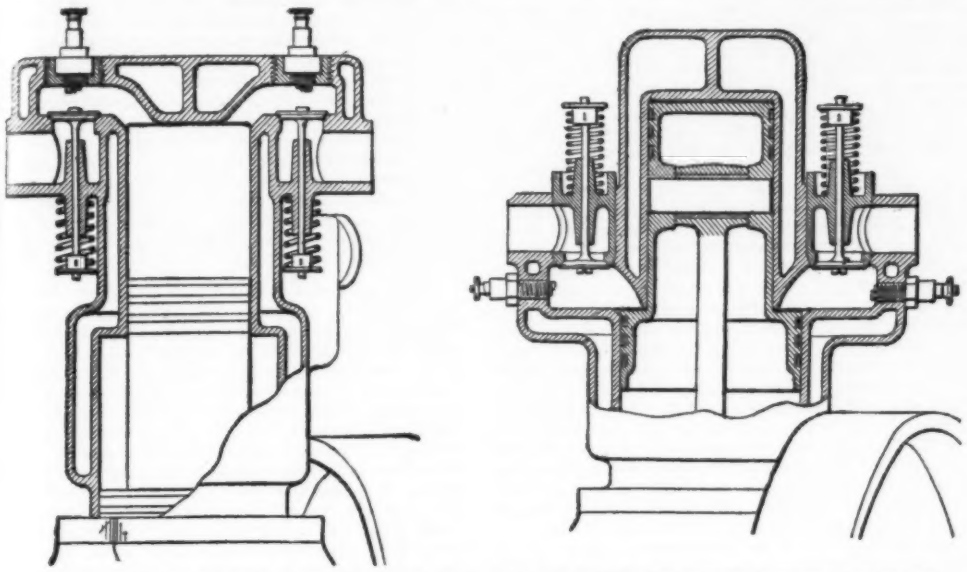


FIG. 4.—CROSS SECTION SHOWING UPPER AND LOWER CYLINDERS WITH PISTONS AT BOTTOM AND TOP OF STROKE.

side of the cylinder, as shown in Figs. 4 and 5. They are operated by vertical push rods, which are moved up and down by suitable valve levers, *i*, *j*, seen from the side in Fig. 2, and from above in Fig. 3. These levers are formed with a ring in their center, and this ring surrounds a double raised-and-depressed cam, *x*, *g*, on the camshaft, *c*, and rides on it by means of two rollers, *o o*, as shown in Fig. 2. The two levers are pivoted at opposite ends on *k* and *l*, and they carry on

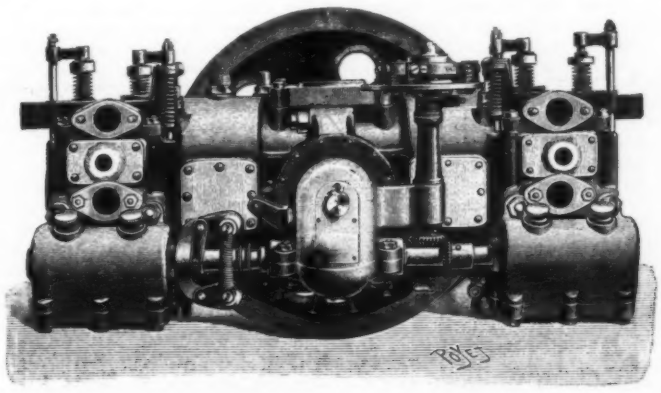
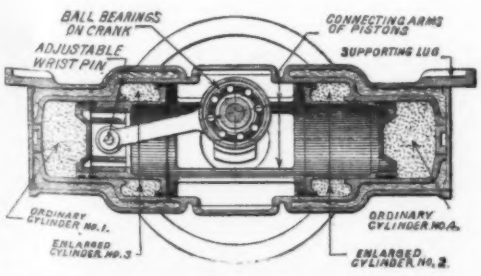


FIG. 5.—HORIZONTAL QUADRUPLEX MOTOR HAVING TWO DOUBLE PISTONS RIGIDLY CONNECTED, A SINGLE CONNECTING ROD, AND A SINGLE BALL BEARING CRANK.

their free ends the valve-operating rods, *n*. By its reciprocating motion each one of these levers operates two valves, one for the upper and one for the lower cylinder on each side of the motor. In Fig. 2 the valve-operating rods, with their brackets, *s* and *t*, for moving the valve stems, *v u*, are plainly shown. The four cams and their settings, as well as a plan view of the valve-operating levers, are shown in Fig. 3. As can be seen in Fig. 2, the two rollers strike the raised-and-depressed cams at the same time, which tends to smooth operation.

The arrangement of the valves on the upper and



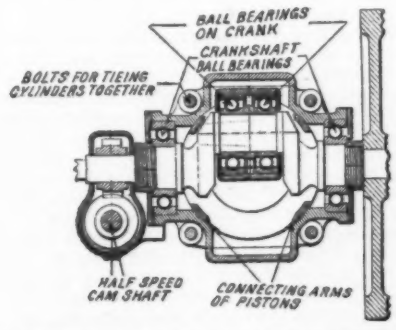

BALL BEARINGS ON CRANK
CRANKSHAFT BALL BEARINGS
BOLTS FOR TIEING CYLINDERS TOGETHER
HALF SPEED CAM SHAFT
CONNECTING ARMS OF PISTONS

FIG. 6.—TRANSVERSE AND LONGITUDINAL CROSS SECTIONS OF QUADRUPLEX MOTOR.

lower cylinders is shown in Fig. 4. As can readily be seen, the charges of gas are compressed in two chambers over the inlet and exhaust valves, and they are fired simultaneously by two spark plugs in the chambers. This arrangement gives very quick ignition and expansion, with resulting high efficiency. A 12-horse-power motor of this type was tested last year for over 200 hours by being direct-connected to a 7,200 watt dynamo, which generated 60 amperes at 120 volts with a fuel consumption of 300 grammes (10.58 ounces) of gasoline per horse-power-hour. As 75 Baumé gasoline of 0.683 specific gravity weighs 11.38 ounces to the pint, and as a pint per horse-power-hour is the usual consumption, there appears to be a saving of 0.8 ounce, or 0.079 pint per horse-power-hour, or about a gallon a day for a 10-horse-power engine running 10 hours. A double-opposed-cylinder motor of this type, in which ball bearings are employed upon a single crank, is shown in Figs. 5 and 6. This is the motor upon which the tests were made, and it is partly owing to the use of ball bearings upon the crank that increased efficiency was obtained. With the improved type of bearings shown the dead center is reduced to a single point, and besides this the friction is greatly diminished, while the wear is almost *nil*, and the life is said to be very great. With the double-opposed-cylinder motor shown, the effect is the same as with a four-cylinder vertical motor, and yet this is obtained with but a single crank and connecting rod—an arrangement made possible by casting the two compound pistons so that they are connected together by four suitable arms, as shown in the cross section. The motor, furthermore, is of the four-cycle type. It is a distinctly novel engine, and shows considerable improvement along original lines. Its makers claim for it a saving of 10 per cent in fuel, 20 per cent in weight, 40 per cent in price, and 50 per cent in bulk over the usual four-cylinder motor, which it is intended to replace. Besides these savings, it has several advantages of construction described above.

SOME PROPERTIES OF MATTER AT LOW TEMPERATURES.*

By Prof. J. S. SHEARER, Cornell University, Ithaca, N. Y.

ONE of the most important elements which influence man's physical existence is the temperature of his surroundings, the very maintenance of life being conditioned on a comparatively narrow temperature range. The change from winter's cold to summer heat undoubtedly gave to prehistoric man his ideas regarding limits of temperature variation, while acquaintance with fire, and in certain parts of the earth with volcanic eruptions and geysers, perhaps gave an extension as regards the question of higher temperature. We are still, however, accustomed to consider any temperature as low which falls very much below the temperature at which ice melts, even though our experience is now extended very considerably beyond that limit. The processes of manufacture which often demand the use of very high temperatures have enlarged our knowledge in the direction until they have become somewhat familiar to most observers. Yet, beyond the reduction secured by ordinary freezing mixtures, temperatures considered as low are by no means familiar to most of us. We may therefore assume that any temperature more than 30 deg. on the Centigrade scale below the freezing point of water may come properly under the definition of low.

The methods employed in the production of these temperatures may be divided into three distinct classes. By the addition of suitable salts to solids it is possible to hasten the process of liquefaction; the heat required to change from solid to liquid state being abstracted from the surroundings gives a temperature reduction. If we use, for example, various salts with ice in proper proportions the temperature of the melting mixture may be reduced to perhaps twenty or thirty degrees below the zero point, depending upon the nature of the mixture. It is not, in general, convenient to use this process with many solids for various reasons. If, however, we choose a mixture of solid carbon-dioxide and ether in proper proportions a temperature of approximately —80 deg. C. may be secured. Another natural process requiring the expenditure of heat consists in the vaporization of a liquid. The conditions under which vaporization continues are more or less under control. Since part of the work done in changing a liquid to a gas consists in overcoming the external pressure which opposes the increased volume from the liquid to the gaseous state, a reduction of external pressure will facilitate the process of vaporization. Increased vaporization, however, demands expenditure of heat and if the process be maintained the temperature of both the liquid and its surroundings will be reduced by the continued change of state. If it were possible to secure a series of liquids whose boiling points were properly spaced a series of controllable temperatures might be secured by boiling these liquids at varying pressures. By a combination of cooling with solid carbon-dioxide and the application of pressure, early investigators succeeded in liquefying certain gases which had previously been regarded as existing only in the vapor state, and by boiling these liquids under reduced pressure a still greater reduction in temperature was secured.

It at first appeared to investigators in this field that since the conditions which determine the physical state of substance are the pressure and temperature to which the body is subjected, and since increase of pressure as well as reduction in temperature always tends to change vapors into liquids, it would be possible by a sufficient increase in pressure to change the most refractory gases into the liquid form. The researches of Andrews showed that such was not the case. He demonstrated that unless a gas be reduced in temperature below a point which is definite and fixed for each particular substance it would be impossible by any increase of pressure to change the material to the liquid state. For example, it would be absolutely impossible to liquefy carbon-dioxide unless the temperature of the gas was reduced below about 34 deg. C. This point, to which the temperature must be reduced before pressure can cause liquefaction, is spoken of as the critical point for that particular substance. It should be noted, however, that simple reduction of temperature would not necessarily produce liquefaction, since to each temperature below the critical one, there corresponds a definite vapor pressure. The further the gas is reduced, however, below its critical temperature the smaller will be the applied pressure necessary to produce liquefaction. The critical temperature of oxygen, nitrogen and hydrogen is much below the lowest temperature attained by boiling ethylene and similar liquids under reduced pressure, so that for many years these came to be named permanent gases and greater temperature reduction was required before they could be liquefied. Another process which results in lowering of temperature is the expansion of a gas against an external pressure. The process of compression of any gas results in the production of a rise in temperature, while the same gas when expanded usually cools. By a combination of the processes above described, Olzewski, Dewar and others succeeded in liquefying oxygen, nitrogen, and air. The first plants arranged for this purpose were, however, exceedingly complicated and expensive. A few years ago Prof. Linde, of Germany, and Dr. Hampson, an English physicist, devised apparatus for utilizing continuously the cooling of gases by expansion from high pressures so as to produce temperatures much below the critical temperature for nitrogen or oxygen, in fact lowering the temperature to

* This is an abstract of a lecture read before the New York State Science Teachers' Association. It was demonstrated with the aid of liquid air.

such a point that these gases would liquefy at ordinary atmospheric pressure. By exhausting the gas rapidly from the vessel containing these boiling liquids a still further reduction of temperature was available.

Let us now consider for a moment the question of probable limits of available temperatures. As regards the higher limit we are not likely to secure a temperature much above that of the positive carbon in an electric arc, especially when designed for electric furnace operation. This temperature has, in reality, never been measured by ordinary methods, but is probably somewhere between three and four thousand degrees on the Centigrade scale. Our idea of the lowest temperature which we might expect to attain is based on the supposition that the pressure exerted by a gas upon the inclosing walls reduces by 1-273 of its value at 0 deg. for each degree of temperature reduction. If then the gas should *remain* a *gas* and should *maintain* the same rate of pressure reduction as the temperature was still further decreased we should expect that at a temperature of —273 the gas would be incapable of exerting any expansive pressure whatever. This supposition is not one which is warranted by our experience with any of the common gases, since they all change from the gaseous to the liquid state at ordinary pressures before a temperature approximately of 273 below zero is reached with the exception of the rare gas helium. A picture of the range of temperatures below zero degrees may be shown by measuring a string 273 units in length as attached here to the ceiling and considering the point of attachment as zero on the Centigrade scale. The first tag attached corresponds to carbon-dioxide mixed with ether, or 80 deg. C. The next corresponds to the critical temperature for atmospheric air, very approximately 130 deg. below zero. The next is the boiling point of oxygen —182.4, and slightly below that the boiling point of nitrogen —195.6.

The next step in the development of low temperatures was one which required careful consideration and a further application of the methods which have already been mentioned. The critical temperature of hydrogen is lower than can be attained by the boiling of nitrogen under reduced pressure, that is, much lower than —210 deg. C. (This temperature has recently been determined and is very closely —240.8.) The Hampson process of liquefaction has been successfully applied not only to the case of oxygen and nitrogen, but also to the case of hydrogen, and because of its simplicity and effectiveness it is coming to be regarded as the standard method for the liquefaction of gases having low boiling points. The general principle of the apparatus may be illustrated as follows:

Suppose we consider a long metal tube having an adjustable valve at one end and connected at the other with a powerful air compressor capable of supplying a considerable quantity of air at a pressure of 3,000 pounds per square inch. If the valve at the end of our pipe be opened expansion to atmosphere pressure will entail a reduction of temperature. This temperature reduction, however, will not be extremely great and would be largely neutralized by the inflow of heat from the surroundings. Suppose, however, that the tube is insulated as far as possible from all heat supply and is inclosed in a second tube so that the gas partially cooled by expansion passes back on the outside of the first tube, regaining its temperature by absorbing heat from the tube conveying the incoming gas. In this way the gas at the expanding nozzle will be gradually reduced in temperature until finally it comes below the temperature at which liquefaction will take place at atmospheric pressure. As a matter of convenience in installation and operation, the tube carrying the gas is wound up in a spiral coil and is carefully protected from external heating by a suitably constructed jacket. Such a liquefier will operate successfully in the case of air without preliminary cooling, but in the liquefaction of hydrogen the gas under pressure must be cooled somewhat below 80 deg. C. before liquefaction can be produced. The effective cooling is due to the slight mutual attraction of gas particles, i. e., to the Joule-Thompson Effect.

The measurement of low temperatures can be accomplished by the use of gas thermometers, thermo-elements, resistance thermometers, or by the use of certain special liquids whose freezing points are extremely low. For the lowest temperatures now attainable, however, a helium gas thermometer or a properly constructed thermo-element is the most practical.

Undoubtedly one of the most interesting substances at low temperatures is air in liquid form. We have in this small beaker a non-viscous, pale blue, liquid whose density is approximately unity, as is readily shown by pouring some on the surface of water and observing the immersion. The surface tension of the liquid is small and the temperature of this particular specimen is probably very close to —188 deg. on the Centigrade scale. The temperature varies according to the relative proportion of oxygen and nitrogen in the mixture. The density also varies with the composition from 1.31 for oxygen to 0.791 for pure nitrogen. Liquid oxygen is slightly magnetic, as may be shown by observing the attraction of a small horse-shoe magnet for the liquid. Liquid air, oxygen and nitrogen behave precisely as any other liquids, excepting that they happen to have boiling temperatures at atmospheric pressure very much below those to which we are ordinarily accustomed. The behavior of liquid air when poured upon a surface at room temperature is exactly the same as in the case of water placed upon a surface extremely hot as compared with the boiling point of water. A layer of gas is developed between the hot plate and the cold liquid which forms a cushion preventing actual contact between the two. If we pour liquid air upon a small glass in the vertical projection field of the lantern we will note that it vibrates quietly for some time without any sputtering or hissing until it finally comes in contact with the glass when it boils much more violently. In common with all other liquids, liquid air has a definite heat of vaporization and it requires the expenditure of approximately 51 calories of heat to convert one gramme of liquid air at its boiling point to gaseous air at the same temperature. If we consider the specific heat of air as constant between its boiling point and 0 deg. C., the total heat required to convert one gramme of liquid air at its boiling point to ice cold air would be nearly 95 calories.

In order to keep the liquid it is necessary to construct vessels which will prevent acquisition of heat, since if the heat of vaporization is not supplied, the air will retain the liquid form. The most successful vessels for this purpose were invented by Professor Dewar of the Royal Institution, London, and are known as Dewar bulbs. They are constructed of glass instead of metal, which prevents the conduction of heat from the surroundings. They are made double walled and the air between the two walls is removed so as to prevent the transfer of heat from the outside to the liquid by conduction or convection of the gas and finally they are frequently coated with a layer of silver which serves to reflect radiant heat and light, thus very effectively preventing heat transfer to the liquid.

Since no pressure, however great, would keep air liquid at a temperature above —130 deg. vessels containing the liquid air must not be tightly closed. Pouring a small quantity into a piece of heavy rubber tubing and closing both ends the pressure developed on evaporation is rapidly shown.

By the use of liquid air as a cooling agent, it is possible to liquefy many gases at comparatively low pressures. Taking a tube containing ethylene which in the field of the lantern is apparently empty, and immersing it for a moment in a bath of liquid air, we find that we have an accumulation of liquid 1 or 2 centimeters deep in the bottom. Were the earth to be cooled to a temperature of —195 deg. C. we should have a layer of liquid upon its surface approximately 35 feet in depth with various solids not especially familiar to us, such as solid carbon dioxide, ethylene, etc., floating therein.

If we consider the effect of great reduction of temperature upon liquids, we find that at the temperature of liquid air, mercury, alcohol, ether, chloroform, etc., have become solids. A test tube filled with mercury gives us a solid which will persist for a considerable time after removal from the liquid and which you see is malleable and not unlike soft lead in appearance. Certain liquids such as pentane and petroleum-ether have freezing points below the temperature of liquid air and may therefore be used in thermometers for low temperature measurement. If we take ordinary coal gas and pass it through a tube immersed in liquid air and observe the character of the flame at the opposite end of the tube we will note that its luminous qualities are greatly reduced, ultimately giving a flame which chemists would recognize as characteristic of burning hydrogen. Cutting off the gas supply and removing the tube from the cooling liquid, we observe that a considerable amount of solid material is present in the bottom of the tube and on the application of heat this solid material changes to a combustible vapor which may be lighted at both ends of the tube and giving a highly luminous flame. Liquid air contains a higher percentage of oxygen than ordinary gaseous air, owing to the fact that the boiling point of oxygen is higher than that of nitrogen and consequently a greater per cent of the oxygen liquefies than of the nitrogen. This fact may be shown by observing the ability to support combustion of vapor from an old sample of liquid air, which has become still richer in oxygen by the more rapid vaporization of the nitrogen, in which ordinary wool burns with explosive violence. Saturated charcoal behaves on ignition very much as gunpowder.

When we come to consider the effect of reduced temperature upon solids, we may say that brittleness, rigidity and tensile strength are in general increased. If we take a small coil of fuse wire incapable of supporting a given weight at ordinary temperatures and retaining its spiral form, we find that upon reducing to the temperature of liquid air the weight is readily sustained, and we may note the gradual straightening out of the coil as the temperature rises. Flowers, beefsteak, and pieces of rubber become extremely brittle at these temperatures, a piece of rubber tubing having elastic properties similar to a piece of glass.

A further peculiar effect may be noted with regard to ability of bodies to store up luminous energy and give it out as light after the exciting source has been removed. Take for example, an egg which has been subjected to liquid air temperature, also a piece of paraffin candle and a tube of solid alcohol and expose them for a moment to the radiation from an arc lamp and then observe them in a dark room. Each glows with a characteristic phosphorescent light, the egg especially giving a beautiful wavering blue color. It might be of interest to observe in this connection that liquid air like ordinary air is a good insulator and that we may have in the same small beaker simultaneously one of the highest and one of the lowest temperatures conveniently attainable, by operating an electric arc beneath the surface of liquid air. Notice that the arc is extremely brilliant and is maintained without serious difficulty.

I wish to call your attention to the fact that the temperatures here exhibited are by no means the lowest which have yet been attained. The following table may be useful as giving certain important temperature points for reference.

Solid CO_2 + Ether	— 79.8 deg. C.
Boiling Oxygen at a pressure of one atmosphere	—182.4
Boiling Nitrogen at a pressure of one atmosphere	—195.5
Boiling O at a pressure of one mm. of mercury	—228
Critical point of air (approx.)	—130
Critical point of Hydrogen	—240.8
Boiling point H	—252.5
Melting point of H	—257
Lowest temperature attainable by use of H (estimated)	—260
Lowest temperature as yet actually measured	—258.5
Estimated temperature by expanding helium cooled to —258	—266.5

I wish you particularly to note that all of the phenomena which you have seen in connection with low temperatures are similar to those open to observation on various substances at ordinary ranges of temperature. In fact, there is nothing contrary to ordinary experience in any of the properties of matter in this interesting field. When first asked to speak to you upon this topic I was strongly tempted to decline because of the sensationalism which has been developed in connection with this topic as well as many others in physical science. A few years ago the unscientific public and many supposed scientific men were greatly enthused by lyceum bureau lecturers on this wonderful liquid, and magazine articles written by a promoter who succeeded in floating the stock of a concern for the manufacture of liquid air. The intense desire of the American public to make money by getting something for nothing was seized upon by the promoter to further his own ends, who stated that when once started the liquid air was self-producing and picturing in glowing terms the tremendous possibilities in the development of power. It is perfectly true that an enormous pressure may be produced by applying heat to liquid air in an inclosed space. But this gives no indication whatever concerning the energy relations involved and liquid air has not proved in any way an exception to the fact that work must be performed in order to get returns. Not only this, but even conservative speculators were imbued with the idea of utilizing this exceedingly cold liquid as a refrigerator agent. A party not 1,000 miles from an institution where accurate information regarding the properties of this liquid might have been obtained, lost about $60,000 in efforts to utilize liquid air for refrigeration purposes. Note that a refrigerating temperature below zero degrees is seldom required in practice and that for this limit 80 pounds of liquid air will be very approximately equivalent to 95 pounds of ordinary ice. Under the conditions of operation in the plant where this air was obtained, the cost of production comes pretty close to $4.00 per liter, including breakage of expensive containers, interest and depreciation, attendance, etc. It is hardly to be expected that refrigerating plants utilizing this liquid would be financially successful.

It may naturally be asked, what is the use of liquid air and of low temperature investigations? As far as the scientific man is concerned, increase of knowledge of nature pure and simple is a sufficient excuse for the expenditure of money and time to any extent. Even to those, who, unfortunately, look only at immediate commercial returns, we may still say that this liquid has proved to be of considerable use and to two cases I especially call your attention. In the preparation of oxygen for medicinal purposes the evaporation of liquid air gives a product much less likely to contain poisonous materials than that obtained by most chemical processes. Another application which may appeal very directly to some of you at some time of your life, is in the production of chloroform for use in anaesthesia. It has been found that the presence of impurities in chloroform adds very greatly to danger to life in its use, and the only way in which perfectly pure chloroform can be practically produced is by freezing out the impurities by the use of liquid air as a refrigerating agent.

In conclusion I wish to urge upon you one and all as teachers to beware of sensationalism and *yellow* science. While maintaining an open mind regarding physical theories and admitting possible limitations of so-called natural laws, you, of all mankind, should stand firmly for the general results of sound scientific experience and not eagerly seize each passing will-o'-the-wisp which the public, still influenced by superstition and mysticism, fondly hopes will, miraculously, enable them to violate natural laws with impunity. How often in the last few years have even reputable magazines joyfully announced the final overthrow of that barrier to the realization of mystic hopes, the conservation of energy. Liquid air, self-regenerating, to drive our flying machines for nothing, radium overthrowing all the ponderous laws of physical science, and to be not only the inexhaustible storehouse of thermal energy, but also the long sought fountain of youth and cure for most diseases. And not a little of this sensationalism is due to those who should be high priests at the altar of truth instead of demagogues selling their birthright for the miserable mess of pottage of popular excitement. The world has a right to expect that teachers and investigators in science should

live up to the highest scientific ideals, and if the educational results of science do not always compare favorably with those of the subjects it has displaced, is it not largely due to our failure to realize its dignity and power? Do not imagine for a moment that I believe physical science should not be made attractive, or that striking experiments may not be legitimate and useful. Is it necessary to surround science with mysticism or to teach what the ripest results of experience contradict, in order to create a transient wonder and to keep up interest in our chosen subject? One who in any small degree comprehends the real wonder of our environment, the subtle beauties of the simplest natural process, visible to those who having eyes really see, can hardly fail to be an attractive teacher, even though building no air castles to obscure the temple of truth. To develop sound appreciation of science, to increase its usefulness in daily life, to make it satisfy the highest intellectual cravings and, finally, to dispel the idea of a vacillating and uncertain mystic ruling power whose laws may be circumvented at will, is the high calling of each and every real teacher of science.

COKE OVEN GAS.*

By C. G. ATWATER.

THE production of coke oven gas is the result of the destructive distillation of bituminous coal under the exclusion of air. The object of such destructive distillation is primarily the production of coke, a raw material for both the blast furnace and gas producer. Incidental to this process is the evolution of the volatile portion of the coal in the form of gas; the gas, therefore, is a by-product. The production of gas by this method is exactly analogous to the distillation of coal in the ordinary gas retort, such as Murdoch used in 1798, in what we are told was the first method invented for the manufacture of illuminating gas, and which in modern form is still an integral part of a majority of existing illuminating gas works. In the retort, however, the gas is the principal product and the coke the by-product. Practically all that will be said in this paper of coke oven gas, as a source of power, would apply equally well to the use of illuminating gas, with the difference that the high cost of generating illuminating gas usually prohibits its use for power generation except in small units and under special circumstances. A short thermal calculation will show the truth of this and indicate approximately the limits with which city gas may be economically used for power generation.

Assuming 650 B. T. U. per cubic foot as the average value of illuminating gas sold at $1 per 1,000 cubic feet, we have 650,000 B. T. U. for $1, or 1,000,000 B. T. U. cost $1.54. Assuming coal at $3 per ton (of 2,000 pounds) having 13,000 B. T. U. per pound a million B. T. U. costs but 8.6 cents. This great discrepancy in cost is reconciled to some extent by the greater efficiency of the gas engine, which delivers, roughly, a brake horse-power per hour from 20 cubic feet of gas, costing 2 cents, whereas the steam boiler and engine combination requires about 3 pounds of coal per hour per horse-power in moderate sizes, at a cost of 0.45 cent. This would be increased somewhat by the cost of coal handling and labor in the boiler house. It is, therefore, clear that illuminating gas at $1 per 1,000 feet has not a wide field as a source of power, but it is also apparent that at a cost of, say, one-fourth or one-fifth the value assumed above, it would become a prominent factor.

In order to make clear the analogy between coal gas made from the gas retort and from the by-product coke oven, the following analyses are submitted as typical:

	Coke Oven Gas.	Retort Coal Gas.
	Per cent.	Per cent.
Methane	39·6	36·02
Other hydrocarbons	5·4	4·75
Hydrogen	37·6	47·04
Carbon monoxide	5·8	8·04
Carbon dioxide	3·5	1·60
Oxygen	0·4	0·39
Nitrogen	7·7	2·16
B.T.U.	693	693

The coke oven gas in this instance is that known as the rich portion, and is given off during the first part of the coking time, this method of operation being known as the division or fractioning of the gases. In this way the more valuable portion of the gas is reserved for illuminating or power purposes, the remainder serving to heat the coking ovens. As coke oven gas for illuminating is usually treated in this way, it is proper to select a fractioned gas for comparison with the illuminating gas from retorts. The principal characteristic of the fractioned coke oven gas is that the methane is approximately the same percentage or a little higher than the hydrogen. This is an advantage in gas engine work, as it diminishes the chance of preignition under compression in the engine cylinder, although in neither case is this liable to give trouble. If there was no probability that any portion of the coke oven gas would be used for illuminating purposes, the fractioning process might be eliminated, and a single condensation system installed in place of a double one. Under these conditions the surplus gas available for gas-engine use would be the average of the whole product, and might be represented by the following average analysis:

Methane, 33.9 per cent; other hydrocarbons, 3.8; hydrogen, 44.4; carbon monoxide, 6.2; carbon dioxide, 2.9; oxygen, 0.3; nitrogen, 8.5 per cent. B. T. U.=620.

In considering the by-product oven as a source of power, the efficiency of the process should be determined. This is shown in the following table of the heat balance, giving the British thermal units originally contained in the coal, and their distribution among the various products recovered:

Distribution of Heat Units in Coal.

100 lb. of dry Coal Yield.	B.T.U. per lb.	Total Calorific power B.T.U.	Per Cent. of Calorific power of dry Coal.
71·13 lb. of coke	12,645	899,456	72·3
3·38 lb. of tar	12,210	51,410	4·1
229 cb. ft. of surplus gas	686	157,504	12·7
234 cb. ft. of heating gas	567	132,835	10·7
Ammonia liquor, sulphur in purifier and loss	—	2,496	0·2
Total=100 lbs. dry coal	—	1,243,700	100·0

These figures are taken from Dr. Schniewind's paper, entitled "The Production of Illuminating Gas from Coke Ovens." From this table it is evident that the percentage of the total heat required for the conversion is 10.7 + 0.2 = 10.9 per cent of the whole heat available. This is an efficiency of practically 11 per cent, and compares favorably with that of any existing method of conversion, though it should be considered that only a portion of the product is in gaseous form.

It may prove interesting to consider briefly the present condition of the coke making industry relative to gas production. The production of coke in the United States for the year 1903 was approximately 25¼ million tons, according to the figures given by the United States Geological Survey; of this 7.4 per cent, or a little over 1¾ million tons was produced in by-product ovens, the balance, or 23½ million tons, being produced in ovens of the beehive type. Assuming the ratio of coke yield given in the above authority, which is 64 per cent, this represents in round numbers, 38.8 million tons of coal carbonized without recovery of by-products or gas, with the exception of certain plants which obtain a small amount of steam by passing the waste heat from the beehive ovens through boilers. The carbonization of this coal in by-product ovens would have yielded on the average 3,500 cubic feet of surplus gas, besides that needed for heating the ovens. At 600 B. T. U. per cubic foot, and allowing 12,000 B. T. U. per horse-power per hour, this would have been equivalent to 175 horse-power hours per ton of coal, or 283 million horse-power exerted continuously throughout the year.

The operation of the by-product oven, and the method of making gas, will be best explained by allusion to a block of the United-Otto type of oven with its auxiliary apparatus; the oven itself, forming a rectangular retort of fire-brick construction, has a capacity of from six to nine tons of coal per charge.

A number of ovens, usually fifty, are arranged side by side to form a battery, the sub-structure consisting of a steel and concrete framework which supports the masonry independently of the regenerative chambers. The ovens are heated by gas burning in the flues, and led in through burners placed in the bottom and end of the oven structure. Air for combustion rises through the checker work of regenerators on one side of the oven, the movements of the air and flame being reversed from time to time through the heated checker work in the well-known manner of heating known as the Siemens regenerative system.

The coal to supply the ovens is brought in on railroad cars, and is elevated to the bin above the ovens. From this bin it is drawn to the coal lorry below, and delivered from this through spouts to the oven beneath, each spout on the lorry coinciding with an opening in the oven masonry. The coal is leveled in the oven by an automatic leveling bar. After the coking time, which is usually 24 hours, the coke is pushed out of the oven by means of a ram or pusher. It is then received in a quencher, having a moving conveyor bottom, from which the coke is discharged after quenching into cars standing beneath it.

The gas evolved during the time of coking is drawn off by collecting mains above the ovens connecting with the oven itself by uptakes in which a valve is placed. These collecting mains are two in number; one serving for the rich gas, which is the fraction coming off during the first portion of the coking time, and the other is for the remainder or fuel gas. These mains connect each with an entirely separate system of cooling and condensing apparatus. The rich gas, of which there will ordinarily be from 3,000 to 4,000 cubic feet, will have from 650 to 700 B. T. U. per cubic foot, while the poor gas, some 5,000 to 6,000 cubic feet, will have from 500 to 600 B. T. U. per cubic foot, the quality of the gas varying with the coal used.

From the collecting mains the gas is led by other mains to the condensing house. As has been already mentioned, the condensation system comprises two separate parts, for the rich and the poor gas respectively. These are arranged in parallel. The gas enters first the air and water coolers, in which it is cooled by the exposure of large surfaces to the air, or by cooling water sprayed over the apparatus. It then passes to the multitubular coolers, in which it is further cooled, the tubes being so arranged that the gas and cooling water pass in parallel, but opposite, directions in order to gain the maximum cooling efficiency. The gas then passes to exhausters which move it through the mains and condensation system. They are so regulated that a slight excess pressure is always maintained on the ovens in order to prevent the inflow of air at any point. The exact pressure on any part of the apparatus is indicated by gage boards placed in the exhauster rooms. From the exhausters the gas passes to tar scrubbers of the frictional type. In these the vapor of tar contained in the gas is caused to condense into drops by the friction caused in passing through baffled apertures, in thin steel plates. Having been freed from its tar, the gas then passes to the ammonia scrubbers which are of the tower type. These consist of vessels filled with wooden grids, which are kept constantly wetted by a spray of water or liquor entering the top, the gas entering the bottom and passing upward through the interstices. On leaving the ammonia washers, the gas should have a temperature of from 60 deg. F. to 75 deg. F. and be free of its tar and ammonia. It may now be considered ready for use in gas engines. With a coal of good quality the sulphur present will not be above the limits that can be safely used in the engine cylinders without the need of resorting to oxide purification. This was found to be the case in a gas engine operated at the Camden plant where the gas was taken just as it came from the condensing house and used with excellent results. A number of gas engines are in use in German coke oven plants without resorting to oxide purification, and in several cases where it was at first installed, it has been found necessary to continue its use.

The ammonia liquor resulting from the condensing and scrubbing operations is manufactured, by distillation and condensation, into strong, crude liquor containing 14 per cent to 18 per cent of ammonia; or the vapors from the ammonia stills are passed through sulphuric acid, forming sulphate of ammonia, which is dried and marketed. At the Theresian Schacht plant at Polnisch Ostrau, Austria, three 300-horse-power gas engines operate on coke-oven gas. These engines are of the four-cycle type, and the gas for their use is passed through an auxiliary scrubbing by water and sawdust, but without means for removing the sulphur. Oxide purifiers were first provided for this purpose, but were not used, the slight corrosion of the valve surfaces which occurs after months of use not being sufficient to justify the cost of purification. These engines were guaranteed to deliver 1 horse-power per hour, from 27 cubic feet of gas of a minimum value of 329 B. T. U. per horse-power hour, which guarantee they successfully fulfilled. They were directly connected to generators delivering current at 575 volts and 6,000 alternations, operating in parallel.

* Journal of the Society of Chemical Industry.

MAGNETIC DETECTORS.—James Russell has measured the effects of parallel and transverse oscillations upon the magnetic properties of iron, with a view to explain the action of the various patterns of magnetic detectors of electric waves. He finds that Marconi's second instrument detects the *increase* of induction which occurs when electric space waves are superposed upon fields at or near a cyclic extreme, in precisely the same way as Rutherford's original apparatus detected, or rather measured, a *decrease* at another point of the cyclic process. The function of the moving band appears to be twofold: First, it supplies the hard iron or steel in a condition of lower permeability, in order that it may be raised to a condition of higher permeability when the signals are received from a distant station; and, second, it distorts the field in the direction of motion, the telephone thus tending to respond in a greater degree to signals received when the field is increasing near, but not at the cyclic extreme. For low field this is the most sensitive part of the cycle. The Ewing-Walter form of detector is essentially different. It is based upon Ewing's hysteresis tester, which measures the drag between field and iron when one of these is revolving. The best speed is stated to be from five to eight revolutions per second, while Marconi obtained good results at a speed of only half a revolution per second. The reason for this great difference is obvious. The Marconi instruments detect instantaneous induction change, while the Ewing-Walter form integrates.—J. Russell, Proceedings, Royal Society of Edinburgh.

John Smeaton, the father of civil engineering, was born in 1724, at Austhorpe Lodge, near Leeds, the son of a respectable attorney practicing in that town. He was educated at the grammar school at Leeds, and he early evinced a great predilection for mechanical pursuits. It is interesting to notice that both Smeaton and James Watt were trained as mathematical instrument makers, and both received their training in London. Smeaton was a man of very high intellect. If anyone wishes to admire his scientific reasoning, they can do no better than refer to the papers which he presented to the Royal Society. Take, for instance, the paper on the "Power of Wind and Water to Drive Mills." It is, and always must remain, a classic among engineeers of how to combine the mechanical art with reasoning faculty of the simplest and clearest nature. Smeaton's reports, when carefully read, are the epitome of the knowledge of the time. He, of course, is well known as the constructor of the Eddystone lighthouse; but in almost every walk of life connected with his profession he was engaged by those who knew him well, and he was revered by all his contemporaries as one of the finest characters and one of the most steadfast workers of his time. It is interesting to notice who were the associates of this man. He was brought into connection with Wedgwood, who was then establishing the potteries which bear his name, with Arkwright, with Hargreaves, with Priestley; and that society, which he must have enjoyed, must have been one of the most delightful that we can contemplate.

GREAT CRESTED GREBE.

By E. L. Turner.

Writing in 1845, Lubbock in his "Fauna of Norfolk" pathetically observes: "It will not happen in our time, but perhaps the next generation may speak of the great crested grebe as we do of the bustard, in the past tense." There is little danger now, however, of the extinction of this bird, in spite of the recent revival of grebe feathers as a fashionable trimming, for these birds are increasing in numbers; while they have been introduced, and thrive well, in many ponds and reservoirs.

It has been my luck to live some eight hours a day, for more than a week, side by side with a pair of these stately and beautiful birds. There are few men more skilled in steering a punt close up to a grebe's nest, without alarming the birds, than Alfred Nudd, of Hickling, to whom I owe my success in photographing the "Loon," as these birds are locally called. Nudd's preparations for my work began some days before I commenced operations. Little by little a small duck punt was edged nearer and nearer the nest, till the nose of the punt was some three feet from the sitting bird; then bit by bit the intervening reeds were cut away, so as to leave a clear path for my camera lens, while the whole of the punt was covered with litter to match its surroundings, and the large end of a black bottle thrust through the rubbish, facing the bird. This introduction of the black bottle is an excellent method, as it enables the bird to get used to the lens, which cannot be hidden when a focal plane shutter is used. After about a week I was taken to the nest, covered up in the little punt, and left. So silently did we glide toward my hiding place each day that I was generally able to see the grebe slip off her eggs, pulling some loose reeds over them as she did so with a swift right-and-left movement of her bill. My camera was screwed to a board placed across the punt as near the nest as possible—some five feet. After focusing and putting in a plate, I had to lie full length in the punt, completely covered with dry litter and reeds, and wait patiently for the bird's return. My first hour was generally spent in quiet meditation on "mostly nowt," as I could hear the angry birds scolding and splashing beyond the reed-beds. When all was quiet I raised my head, and then the excitement began. One or both of the grebe would be sitting close at hand, the beautiful head and crest raised in a suspicious manner. On some days one bird would sit sometimes in this manner for a couple of hours or more, while on others both would glide to and fro consulting and chatting, or diving in the manner peculiar to their species. They have a way of gradually sinking the body till only head and neck appear above water, and then the actual dive is accomplished without raising a ripple. Yet again, on other occasions, the grebe would pursue quite different tactics. She would swim up to the nest in a bold, business-like manner, so that I was continually on the alert, expecting her to jerk herself up and on to the eggs. One could trace the workings of her irresolute feminine mind in her eye, as she repeated this maneuver time after time, till my numb fingers refused to feel the ball tubing. Then I would relax nerves and muscles, and, carefully sinking my head on to my arms, would drop asleep, which meant my lady had summoned up the necessary courage at last. At first I used to expose my plate immediately the bird had settled, but as I

GREBE UNCOVERING HER EGGS.

became acquainted with her vagaries I would let her sit quietly some time before doing so. It was a keen pleasure to watch her movements. Only those who have seen this glorious bird "at home" can form any idea of the beauty of the plumage.

For the third picture I waited more than an hour before squeezing the ball, and was well rewarded for my extra patience. At first she seemed suspicious, and I dared scarcely breathe; she kept her keen eyes fixed in my direction for some minutes, so that I trembled lest she should penetrate my disguise. The slightest stirring of a reed would have scared her away when in this mood, but gradually she calmed down and then went to sleep. The jarring of the

THE GREAT CRESTED GREBE.

focal plane shutter must in this instance have become part of her dreams, for I almost managed to change my plate without disturbing her; but at the critical moment the dark slide stuck, and made a clicking noise as I drew it out, at which she took fright and dived. It really was terribly exciting watching her expression, and calculating how much more noise she could stand. The process of changing the plate occupied some minutes, as it had to be done slowly and quietly. One half second more and I should have achieved a triumph. I seldom exposed more than two plates a day, one in the morning (generally about noon) and one about four in the afternoon, retiring to my houseboat between times to develop the plate and stretch my cramped limbs. Nudd's face would beam with joy over each successful effort. "That there old grebe 'ull be coming to tea along o' you, Miss," he exclaimed one day; "she shall have a medal, she shall."

Later on, after she had been resting some time, the male bird swam up to see if his mate was quite comfortable, and finding her a little too much exposed on my side, began bringing her decayed reeds and weeds, which she arranged as best suited her taste. He has just been doing this in the fifth picture, while the last shows this grand bird in all the glory of erect crest and "ears." When the grebe has been waiting among the reeds I have been much struck with the protective coloring of the rich chestnut cheeks and olive brown crest and ear-tufts. Several times I found myself staring hard at what appeared to be dead and decaying reeds, such as often cling to the base of the "colts," as Broadsmen call the young green reeds, but the sudden twinkling of a bright eye would warn me that the apparently dead reed was very much alive and interested in my hiding-place.

The newly-hatched grebe is fairly active for his hours. He is a pretty little striped thing, with a crimson spot on his forehead, but his markings harmonize well with the dead weeds of which the nest is composed. A helpless-looking little chap just slipping off the nest one day had not long left the shell, for he was scarcely dry; yet he scrambled into the water before I could get a really good photograph of him. The nest, which looks like a mass of wet muddy weeds, is not as cold and damp as one might suppose. Mr. Thomas Southwell has taken the temperature of several nests and found them to be veritable hotbeds, varying in temperature from 67 deg. to 72 deg. at different stages. My photographic experiences go still further to prove this, for although the eggs in the nest figured here were left exposed many hours a day, they were successfully hatched off in due time. These eggs, when fresh laid, are pure white, but soon become discolored from their surroundings. They vary in number from three to four, rarely five. The first picture shows the eggs partly covered in the manner already described. The baby grebe is an expert in diving, and he takes his first lesson from his parent's back. I have often tried to get within photographic distance of a family of grebe, but so far in vain. If pursued they one and all glance at you with withering contempt, dive, and reappear just too far away, shaking the shining drops from their heads in defiance and inviting you to further pursuit. You may play this game as long as you like, but in the end the grebe will win.—Country Life (London).

To Render the Soles of Shoes Waterproof.—Dissolve 4 parts of tallow in 16 parts of olive oil, add 1 part of spermaceti and 1 part of wax.—Les Corps Gras Industriels.

CATCHING WHALES IN STEEL NETS.

Away down in the South Pacific, on the northeast shore of New Zealand, is the most remarkable fishing station in the world. The men of that station fish for whales and catch them in nets.

New Zealanders have the Yankee faculty of adapting methods to new conditions and doing old things in new and original ways, regardless of precedent and use and wont. The New Englander developed and perfected the business of hunting whales and taking them in the open sea with harpoons. The newest Englander has improved on the Yankee method and has the audacity to treat a whale as if he were no more formidable than a mackerel.

What first suggested to the New Zealanders the feasibility of netting whales I do not know, says a correspondent of the San Francisco Chronicle, but there is a Maori legend so suggestive of this most modern development of the whale fishery that one is inclined to think that the hint was conveyed by the myth.

Many of the old Maori tales have to do with a mythical monster called "Taniwha," usually described as a great lizard or crocodile, although it has been many centuries since any of the Polynesian race can have had direct knowledge of the existence of such an animal. There are no evidences that any animal resembling a crocodile has existed in New Zealand or any of the South Pacific islands since man appeared on earth, yet the Maoris describe it very closely and have carved representations of gigantic lizards. The Maori race has been traced back to India, and it is assumed that the "Taniwha" myth is the survival of ancient knowledge. The "Taniwha," however, is not a fixed type, but may be any sort of monstrous beast, reptile, or marine creature of ferocious disposition and terrifying aspect, superstitiously feared and often half worshiped as a tribal protector by the imaginative Polynesian.

This is the tale of the two Taniwhas, the guardian monsters of the two Maori tribes; one on the east coast and one on the west coast of the North Island of New Zealand in very ancient times. The Taniwha living in the Bay of Islands once went a-roving to see a bit of the world and swam around the North Cape to the west coast, where he met the other Taniwha and was hospitably entertained.

The wandering Taniwha professed to be very grateful for the hospitality and kind attention shown to him, and when his visit was ended he pressed the other to accompany him home, promising to show him many interesting things and to make his visit a continuous round of pleasure, or perhaps "one grand, sweet song." The guileless and amiable west coast Taniwha accepted the invitation, and away the two friends swam around the North Cape and down the east coast to the Bay of Islands.

The roaming Taniwha was a perfidious villain. He lured his confiding guest to a place where the Maoris had spread a great net, and the visitor was caught, dragged ashore and killed by the people, who made a great feast of his carcass.

The most contemptuous insult a Maori could put upon an enemy was to bake and eat him, and of course the eating of a guardian Taniwha was a monstrous affront to his people. War ensued and the two tribes ate each other and passed out of history.

Now whether that legend of the Taniwha is as old as it purports to be, or is of recent origin and based upon some Maori story teller's observation of the whale fishing at Wangamumu, is matter for specu-

A GREBE ASLEEP.

lation. If it is really an ancient tale as it stands, and not a modernized version of some old legend, it is a strangely prophetic product of the Maori imagination, for right where the Taniwha was caught in a net the white man to-day nets whales on their way around the North Cape.

Wangamumu is a small bay on the east coast a few

miles south of a prominent headland which juts out to the northeast and might readily be mistaken for the extreme north end of the island. During May and June the Antarctic whale migrates northward into warmer waters, and it is probable that there is a set of current around the headland which deceives the whale into seeking a passage to the Tasman Sea by boring into the shore at that point. Whatever may be the reason, the fact is that schools of whales hug the shore and pass very close to a great jutting rock at Wangamumu.

Straight out to sea from the point of rocks is laid the whale net, made of three-quarter inch wire rope in six feet mesh, each mesh being formed of separate sections of rope attached to iron rings taking the places of knots. The top edge of the net is held close to the surface by barrel buoys. From a lookout station on the headland a watcher signals the approach of whales, as the man in the top used to hail the deck with "There she blows!" and boats then put off beyond the net and lie in wait.

A whale cruising along the shore strikes the net and gets his head through a mesh, and instead of backing out he rushes forward and entangles himself in the wire ropes. He may carry the net away from its anchorage with the momentum of his rush, but the weight of the rope and the drag of the buoys impede him, and instead of heading out to sea and taking the net with him, the whale thrashes about furiously and soon gets the wire ropes wound about his fins and flukes.

When the whale is completely entangled and has wearied himself with his futile thrashing and plunging the boats creep in upon him and the harpoon and lance are used, as in the old days, but there is no tow to sea at the end of a hundred fathoms of line, and there is but little danger of a boat being smashed in the death flurry.

Not all the whales passing Wangamumu run close enough to shore to be caught in the net, however.

Often the whalers of Wangamumu put out to sea and give chase in the old-fashioned way. Power launches are used in the chase, but when a large school of whales is sighted all the boats put out, some of them the old style whaleboats carried by the ships that sailed from Nantucket, and the whalers get back to first principles. Their most dangerous quarry is an old cow whale, lagging behind the school with her calf. It would be easy to kill the calf, but no whaleman who knows his business molests the youngster while the old cow is alive.

The calf swims slowly, and as the cow will not leave it the boat easily overtakes her. Standing in the bow the harpooner signals to the steerer with his hand, and the boat is got into position for the cast. There may be a bit of sea lopping, and some dodging about is necessary to get alongside, but when the opportunity comes the harpoon whizzes through the air and, if well cast, strikes the cow behind the shoulder just above the water line.

Down goes the whale, and before the boat can be backed clear she is up again, beating the sea into foam. Up go the flukes, and the oarsmen back frantically. Down come the flukes with a crash, and the men in the boat are lucky if they only stave a plank in the side.

A minute's furious thrashing, and then the sixty-foot leviathan is off at a rate which draws the line

SETTLING DOWN.

smoking over the bow. If it be an old-style boat, the men unship their oars and take a tow to sea, wondering whether the whale will tire of dragging them or "sound" and take out line until they have to cut it and let her go. If it be a power boat, every pound of steam is put on to follow and keep the line. If all goes well, the whale tires or remembers her calf and slackens speed. The boat creeps up to her, and the lance puts an end to her struggles. The calf is then secured, and the power launches tow them both into the bay, where they are hauled up close to shore and cut up.

In the old days only the blubber of whales was tried out for oil, the rest of the creature going to feed

HUSBAND AND WIFE.

the sharks. At Wangamumu all parts are utilized. The bones are used for various purposes, and the other refuse is desiccated and ground up into fertilizer, and even converted into fuel. The process is accompanied and characterized by phenomena which make the whaling station at Wangamumu a place to be passed on the windward side.

IS "THE AGE OF BRONZE" A MYTH?

By FR. GUENTHER.

THE adherents of the theory that an age of bronze intervened between the stone age and the iron age, base their belief in the first place upon tradition. It is true that the Greek poet Hesiod mentions a bronze age antecedent to the iron age in which he lived, but that this order is purely speculative is evident from his intercalation of the fabulous "heroic age" between the ages of bronze and iron. If we follow Hesiod we must assume the existence of a still earlier "age of silver," which would be absurd. Homer adorns his heroes with gleaming bronze but he also sings of the clang of iron weapons and he makes no mention of the manufacture of bronze by melting copper and tin together. In Homer's day copper and bronze were still imported wares; but even Herodotus, in whose time the working of bronze had attained its highest development in Greece, describes ordinary tools as being made of iron, and assumes that iron tools were used in building the Pyramids. When it is added that the Roman poet Lucretius asserts that iron was used earlier than bronze, it becomes evident that tradition gives no support to the hypothesis of a bronze age antedating the age of iron.

As little support is obtained from objects found in graves and ruins. As iron oxidizes much more rapidly and completely than bronze, it is only under peculiarly favorable circumstances that a bit of iron is preserved for thousands of years, yet many rusty iron implements have come down to us from a time in which we have no evidence of the use of bronze.

Archeologists can attain certainty on this mooted point only by accepting the evidence of metallurgy. The answers to the technical questions that suggest themselves are fully given in Prof. Beck's "History of Iron."

It has been asserted, for example, that the ancient Britons obtained bronze directly from mixed ores of copper and tin. This is impossible. The tin would be entirely oxidized long before the copper began to melt. Besides, the Cornwall copper ore, like all sulphurous ores, must be roasted before smelting. Bronze can be made only by adding metallic tin to smelted copper.

Natural deposits of metallic copper may be left out of consideration, as they exist, in appreciable quantities, nowhere except in the Lake Superior region in America. Copper is most easily obtained from oxide ores, which are reduced by heating them with burning charcoal. But the melting point of copper is about 1100 deg. C. (2000 deg. F.), and while iron, which melts at 1200 deg. C. (2200 deg. F.), softens and can be worked at as low a temperature as 700 deg. C. (1300 deg. F.), copper cannot be extracted from its oxides without heating them above its melting point. Its preparation from sulphurets (copper glance, copper pyrites, "horseflesh copper") is still more difficult.

In order to produce a temperature of 1100 deg. C. (2000 deg. F.) it is necessary to employ, in addition to concentrated fuel, a closed furnace and an artificial draft of compressed air. These things imply high development of the art of metallurgy, and among the uncivilized tribes, ancient and modern, who have mastered primitive methods of obtaining and forging iron, not one has ever been found able to reduce the ores of copper.

The discovery of bronze can have been made only by a people of considerable metallurgical knowledge who were already in possession of both copper and tin. Now, tin ores are found in very few parts of the world, of which the only ones known to the ancients are Cornwall and Devonshire in England, Persia, Afghanistan, India, and the Indian Archipelago.

The resemblance of the Greek word for tin, *Kassiteros*, to the Arabic *Kasdir*, the Aramaic *Kastir*, and the Sanskrit *Kastira* suggests that tin first became known to the Semitic peoples. Bronze was first made by the Semites of western Asia, or perhaps by the Turanian aborigines of the lower Euphrates.

The inhabitants of Europe, while some of them were yet in their stone age, though others had learned to make iron of poor quality, became acquainted with bronze through the Phœnicians, whose lucrative commerce in this alloy was shared by their colonies, by the cities at the mouth of the Po and by the Etruscans until it passed into the hands of the Greeks and Romans.

This is the only sense in which it is correct to speak of a bronze age in Europe. The theory that the lake dwellers of Switzerland, remote from the nearest source of tin in Britain, or the inhabitants of Denmark, where neither copper nor tin is found, independently discovered the art of casting bronze and at once practised it in the most perfect manner, is absolutely untenable. The fundamental similarity of ancient European bronze weapons proves their common origin.

The lake villages built on piles, whose inhabitants possessed metal weapons and implements, are found only in the western part of Switzerland, in the direct path of the ancient commerce of Italy with France and Germany, and the transition from stone to metal is so gradual as to preclude the assumption of the immigration of a bronze-using race. The bronze must have been an article of commerce. Probably the Swiss lake dwellers knew how to melt bronze and convert it into new forms, but most of the bronze objects found in villages, and especially the finer ones, were imported.

Nor is the existence of a bronze period, separated in time from the iron period, proven by Moriot's analysis of the layers in the railway cutting at Villeneuve, for at many points objects of stone, bronze, and iron were found side by side. The fact that iron was employed for objects of little value, such as sockets for the masts of boats, proves that it was cheaper than bronze and was a domestic product.

Quiquerez, a Swiss mining official, has discovered in the Jura alone the sites of 460 ancient iron foundries, in many of which implements of bronze and stone were found. This proves that iron was known as early as bronze, and even in the stone age, though for a long period the use of iron was restricted by the importation of better formed and more serviceable bronze implements from the south.

Scandinavian archeologists assert that bronze was the first useful metal known to the north of Europe, that the fine ornamental bronze objects in the museums

WITH CREST ERECT.

of Copenhagen and Stockholm are of domestic manufacture, and that from 800 B. C. to 200 A. D. Scandinavia supplied all northern Europe with articles of bronze that vied in technical and artistic excellence with those of Greek and Etruscan manufacture. The only point on which these archeologists are not agreed is whether the neolithic population was conquered by

an invading bronze-using race, or itself developed the art of making bronze through the instigation of imported bronze articles.

Whence these bronze makers obtained copper and tin, why it happens that the oldest articles found are the most artistic, why this highly-gifted Scandinavian race for a thousand years remained unknown to the rest of Europe, paid no attention to the iron ore under its feet, founded no cities, erected no substantial dwellings, made no common tools, and did not even learn the art of writing—why, in short, it devoted all its energies to making ornamental bronzes and in other respects remained in the stone age—to these questions the archeologists give no answer. As a matter of fact, many iron implements have been found by Nilsson, Worsaae, Prince (now King) Charles of Denmark, and others, always mingled with stone implements, showing a gradual transition from the use of stone to that of metal and proving that the Scandinavian bronze age is a pure fiction.

No doubt the Scandinavians, like other half-civilized tribes, knew how to melt bronze and cast new tools from the fragments of old ones, for the melting point of bronze is far below that of copper and little higher than the welding temperature of iron attained in the primitive manufacture of iron implements.

Now let us glance at that land of marvels, Egypt. The pyramids of the first, the labyrinth of the second, and the temples of the third period prove, not only that the Egyptians possessed extensive mathematical and mechanical knowledge, but also that they had excellent tools. Porphyry, basalt, granite, and syenite are very hard and can be cut only with steel chisels.

In the fourth dynasty, when the pyramids were built, bronze was yet unknown in Egypt. Tin ore does not occur in Egypt and tin is not mentioned in lists of tribute or spoils of war. The so-called "chisel" of Thebes, which is of the eighteenth dynasty and the only bronze object of the sort found in Egypt, could not have been used in stone cutting, as stone quickly turns its edge.

On the other hand, there is abundant evidence that the Egyptians were acquainted with iron—not the soft, spongy iron of barbarian races, but *steel*. Among iron or steel implements found in Egyptian tombs are surgical instruments with ivory handles, arrow and lance heads and a sickle discovered by Belzoni between the paws of a sphinx at Karnak. In mural paintings butchers are shown using blue whetting steels. In 1877 Hartland discovered in the Sinai peninsula, near the copper mines of King Sephuris, extensive opened deposits of iron ore and great masses of slag. Ancient iron mines have also been found in the mountainous district between the Nile and the Red Sea. In 1837 Hill found, in a crevice of the Great Pyramid of Cheops or Chubu, protected from the sands of the desert by the stone above it, a fragment of a large iron tool that had evidently been dropped there during the erection of the pyramid, more than 4,900 years ago. This oldest known specimen of iron, which has been proved to be not of meteoric origin, should convince the most skeptical. Old Herodotus was not one of these, for, after quoting an inscription to the effect that the workmen consumed 1,600 silver talents (about a million dollars) worth of radishes, onions, and leeks, he remarks: "How great a sum must the iron tools have cost."

The proof that in America the age of iron was not preceded by an age of bronze is also given in Dr. Beck's book.

Of the period of Montezuma I. we have two very beautiful carvings in basalt, the Humboldt Calendar and the Stone of Sacrifice, executed with unsurpassable sharpness and purity of line, and La Condamine discovered in Peru heads of animals with movable nose rings, the head and ring being carved out of a single piece of porphyry. These carvings alone are sufficient to prove that the Mexicans and Peruvians had steel cutting instruments, but in America temples and other edifices, fortifications, viaducts, tunnels and subterranean galleries constructed of the hardest of stones—porphyry, basalt, granite, and syenite—are found more abundantly than anywhere else on earth, and many of them rival the famous structures of India and Egypt in beauty and technical perfection.

Humboldt thought that all these ancient American buildings were constructed with the aid of bronze tools, but the experiments of Rivero, Tschudi, the Musée de Cluny, and Dr. Hostmann have proved that even hard wood cannot be worked with the ancient American bronze tools, which contain only 4 to 10 per cent of tin.

The green jade of Peru and the black amphibole of Mexico have the useful properties of our flint—Petrus Martyr made notches in an iron bar with the jade ax given him by Columbus; but, like flint, they are entirely unsuited to the carving of hard stone, and the black obsidian of which the Mexicans made razors is as brittle as glass. Tools made of these materials were much used in ancient America in working gypsum, tufa, and soft limestone and sandstone, of which common buildings were constructed. The city of Tenochtitlan contained 60,000 houses built of fragile red tufa.

The assertion that iron was unknown in Mexico was first made by Pietro de Augleria, who never visited America. Cortez and Pizarro and their companions do not mention the subject. Nor do any of the earlier chroniclers note the absence of iron in Peru. On the other hand, Sahagun, who visited Mexico in 1520, speaks of smiths so skillful that they cut iron like wax. The Inca and Araucanian languages had words for iron and ironworking. The Mexicans called iron "black copper," as they called silver 'white gold." Montesinos, an early explorer of Peru, speaks of iron mines, and the ruins of many others have recently been discovered.

The fact that no ancient American iron tools have come down to us is explained by the very rapid oxidation of iron in a hot and moist climate.

We are therefore forced to the conclusion that there is no country and no race on earth in which an age of bronze has intervened between the ages of stone and iron.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Umschau.

[Continued from SUPPLEMENT No. 1596, page 25575.]

VALUABLE ALLOYS.—VI.

ALLOYS OF MERCURY OR AMALGAMS.

MERCURY is well known to be the only metal which is liquid at ordinary temperatures. The best mercury is crystalline in character, and of a silver white color, freezing at —40 deg. F. and boiling at 662 deg. When compounded with other metals, it forms alloys whose properties differ greatly according to the nature of the metals used. In most cases the amalgams are at first liquid, and afterward become crystalline, any mercury in excess being separated.

The amalgams offer an excellent opportunity for studying the behavior of the metals toward each other, the low temperature at which these compounds are formed making the examination easier. If a metal is dissolved in mercury, with an excess of the latter, a crystalline compound will soon separate from the originally liquid mass. This is the amalgam, whose proportions can be expressed according to fixed atomic weights, and easily obtained by removing the excess of mercury by pressure. Many amalgams are at first so soft that they can be kneaded in the hand like wax, but become hard and crystalline in time. These are especially adapted for filling teeth, and much used for that purpose. Before the action of the galvanic current upon metallic solutions was known, by means of which certain metals can be separated in a pure state from solutions and deposited upon a given surface, the amalgams were of great importance in gilding and silvering. The article was coated with the amalgam, and the mercury volatilized by heat, the gold or silver remaining upon the surface as a coherent coat. The process was called fire gilding.

The chemical affinity of other metals for mercury varies greatly; many combine with it very easily, others with such difficulty that an amalgam can only be obtained in a roundabout manner. Amalgams are of great interest theoretically, and important to a general knowledge of alloys, but only a limited number are actually employed in the industries.

Gold Amalgam.

Gold belongs among those metals which combine easily with mercury, and a gold amalgam can be prepared by direct union of the two metals. If gold is used which has been obtained by the chemical process of reducing gold-salts, it must be remembered that this, being in a finely divided state, will not dissolve easily in the mercury, for the reason that the fine powder will remain floating upon the surface. Gold, however, which has been reduced in the form of somewhat larger crystals will dissolve in a comparatively short time. These small gold crystals can easily be obtained by dissolving gold chloride in amyl-alcohol and heating the solution to the boiling point, whereby the gold will be separated in the form of small, lustrous crystals.

Gold amalgam is procured in large masses in the process of obtaining gold from auriferous sand, and by subsequent heating in iron retorts the combination is decomposed, the mercury volatilizes and the pure gold is left behind. Gold forms with mercury a chemical combination, Au_2Hg, which has a strong tendency to crystallize. This must be prevented as much as possible in preparing the amalgam, since it is difficult to use a crystalline amalgam for gilding.

A particularly good amalgam for fire gilding is prepared as follows: Place the gold in a graphite crucible, rubbed on the inside with chalk to prevent adhesion, and bring the crucible to a red heat. It is not absolutely necessary to use chemically pure gold. Alloyed gold will answer the purpose, but it should be at least 22 carats fine, and preferably alloyed with silver instead of copper. Gold amalgam containing copper will become as hard as stone in a short time, and even a small percentage of copper makes it difficult to apply the amalgam uniformly to metallic surfaces. It is best to use the gold in the form of thin sheets, cut into small pieces before being put into the crucible. When it is red hot, put into the crucible about the eighth or ninth part of the weight of the gold, previously heated to boiling. Stir constantly with an iron rod, and after a few minutes remove the crucible from the fire. If the amalgam were allowed to cool in the crucible, it would become strongly crystalline, and could not be used for fire gilding; as soon, therefore, as the crucible is taken from the fire, the contents are poured out into a larger vessel filled with water, so that it may cool rapidly. The amalgam will crystallize in spite of all, if kept for any length of time; it is therefore advisable to have it freshly prepared a short time before use. In crystallizing, the amalgam separates from the mercury in excess. If this has happened, it may be restored to its proper condition by heating in a crucible with an excess of mercury.

In the preparation of the amalgam, as well as in the process of gilding, it is necessary to use a wind-furnace with a well drawing chimney, as the vapors evolved from the mercury are injurious to health.

Silver Amalgam.

The properties of silver amalgam are similar in most respects to those of gold amalgam, but it has a still stronger tendency to crystallize. Pure silver must be used in its preparation, as a content of copper would have the same detrimental effect upon the character of the amalgam as in the case of gold amalgam. The easiest method of making silver amalgam is by the use of silver in powdered form, obtained by reducing silver solutions. If a solution of nitrate of silver is put into a bottle with ten or fifteen parts of water, and a few small pieces of sheet zinc, and the mixture shaken vigorously for a few minutes, the silver will separate in the form of a very fine blackish gray powder, which only needs washing and drying to be ready for the preparation of amalgam. This powder can be directly dissolved in the mercury, but it takes some time. A quicker method is to heat the mercury nearly to the boiling point in a crucible, and throw in the powdered silver, stirring vigorously with an iron rod.

Silver amalgam can also be prepared without heat. In this method, a concentrated solution of nitrate of silver (one part of the nitrate in three of distilled water) is mixed with four times the quantity of mercury, and the liquids combined by shaking. The silver will be reduced from the nitrate by the mercury, and dissolve in the excess of it. If the amalgam is to be used for fire-silvering, the small quantity of nitrate of mercury adhering to it is of no consequence, and it can be used at once.

Fire Gilding.

For fire gilding or silvering only a pure amalgam is used, such, namely, as is freed as far as possible from an excess of mercury. For the purpose of removing this excess, the amalgam is tied up in a bag of strong chamois leather, and subjected to a gradually increasing pressure, whereby the mercury is forced through the pores of the leather. This pressed-out mercury contains a considerable quantity of gold or silver, and can be used in making fresh amalgam.

Fire gilding or silvering is of course only employed with metals which will stand a temperature near that of the boiling point of mercury without melting. The amalgam will adhere only to perfectly bright metals, and the articles are subjected, before gilding, to a preparatory process, which consists in bringing them to a red heat, whereby the grease, dust, etc., adhering to the surface are burnt away, and the metal becomes covered with a film of oxide. They are then dipped into a mixture of three parts of nitric acid and one of sulphuric acid, which quickly dissolves the oxide, leaving the metal with a bright surface. Articles which are to be heavily gilded must remain longer in the acid mixture, as a rougher surface is essential to the adherence of a large amount of the amalgam.

The articles are rinsed in water, without touching them with the hands, and left in water until they are to be amalgamated, this being to prevent oxidation. The so-called amalgamation process consists in covering them with a layer of metallic mercury. The amalgamating water is prepared by dissolving 100 parts by weight of mercury in 110 parts by weight of strong nitric acid, and adding 25 parts of water. It is applied to the surface of the metal with a brush of fine brass wire. By the action of the metal upon the mercury salt, the latter is reduced to metallic mercury, in the form of very small drops, which give a white color to the metal.

When the articles are thoroughly amalgamated, the amalgam is applied with a stiff scratch-brush, quickly and evenly, and they are then placed upon glowing coals. The mercury evaporates, and the gold or silver is left in a coherent layer. During the process of heating, the articles must frequently be removed from the fire, and the amalgam re-applied to defective places.

The workmen employed in the process suffer greatly from the fumes of the evaporating mercury, and it must be carried on in a thoroughly well ventilated apartment, or still better, in the open air. In spite of all precautions, however, the work is very dangerous to health, and for this reason fire gilding, though more durable than any other, is falling into disuse.

Many articles are not finished by one gilding, but the process is repeated two or three times, to give a thicker coating of gold. By suitable treatment during heating, and by burning off the so-called gilders' wax, a coating of which is given to the finished article, various shades of color can be obtained.

Amalgams of the Platinum Metals.

The platinum metals can be combined with mercury, but the amalgams thus obtained have not thus far found any extensive use in the industries, the process of electro-plating being almost exclusively employed in such cases.

Copper Amalgam.

The peculiar properties of copper amalgam give it quite an important place in several branches of industry. It crystallizes very easily, and becomes so hard that it can be polished like gold. It can also be hammered or rolled, and stamped, and retains its luster for a long time in the air, unless the air contains hydrogen sulphide, in which case it quickly tarnishes and turns black. If placed in boiling water it becomes soft, and so pliable that it can be shaped into the most delicate forms, hardening again in a few hours to a very fine grained, quite malleable mass. It was formerly recommended for filling teeth, but is no longer used for that purpose, as there are other amalgams equally suitable, and free from copper, which has a poisonous effect. An important use of copper amalgam is in cementing metals; it is only necessary to apply it to the metals, which must be bright and

previously heated to from 176 deg. to 194 deg. F., and press them together, they will be joined firmly.

There are many methods of preparing copper amalgam, but the simplest and easiest is as follows: Place strips of zinc in a solution of copper sulphate and shake vigorously. The copper thus obtained, in the form of a delicate powder, is washed, and treated, while still moist, in a rubbing-dish, with a solution of mercurous nitrate. Hot water is then poured over the copper, the dish kept warm and the mercury added. The contents of the dish are kneaded with a pestle, until the powdery copper has combined with the mercury to a plastic mass, which will become the more homogeneous, the longer the kneading is continued. The best proportions are three parts of copper to seven of mercury.

When the amalgam has reached the proper consistency, the water is poured off, and the soft mass molded into the form in which it is to remain. For the purpose of cementing, it has been found best to roll it into small cylinders, about ⅛ of an inch in diameter and ¾ to 1½ inches long.

To take impressions, with this amalgam, of casts made from wood carvings, the amalgam is rolled out, while warm, into a thin sheet, and pressed firmly upon the cast, also warmed. After the amalgam has hardened, the thin sheet can be made stronger by pouring over it melted type-metal.

The so-called Vienna metal cement consists of the amalgam just described; and the so-called imitation gold, which, on account of its golden color and capability for taking a high polish, serves a good purpose in the manufacture of cheap jewelry, consists of copper 86.4 parts and mercury 13.6. As this alloy is very susceptible to hydrogen sulphide, it is advisable to give the articles a thin coating of pure gold, by electroplating.

Tin Amalgam.

This amalgam was formerly of importance for making mirrors, but at the present day mirrors coated with a thin layer of silver are more beautiful and cheaper than those prepared with amalgam. Tin has a great affinity for mercury, which makes the preparation of the amalgam easy. It is only necessary to rub the two together, the tin being best used in the form of foil or shavings. The amalgam will harden in a shorter or longer time, according to the quantity of mercury used.

Tin amalgam for filling teeth is prepared by rubbing together one part of tin and four of mercury, removing the excess of mercury by pressing in a leather bag and kneading or rubbing. It is a flexible mass, which hardens in the course of a few days.

Amalgam for Mirrors.—Amalgam for coating mirrors is the completely saturated compound of the two metals, hardened in a crystalline form. It is prepared directly upon the mirror plate, by the following method. A sheet of tin foil, somewhat larger than the mirror, is placed upon the silvering table, which has a marble top, adjustable by screws, to either a horizontal or inclined position. After the sheet of foil has been spread out and made perfectly smooth, a small quantity of mercury is poured over it, and evenly distributed by means of a woolen cloth. When the whole sheet has been dampened with the mercury, more is poured on, to make a layer about ¼ of an inch deep, and the plate of glass, first thoroughly cleaned (which is best done with strong soda lye), is laid upon it. To do this, a strip of paper is pushed in between the mercury and the layer of amalgam, at one side, the edge of the glass laid upon it and the plate is then pushed slowly forward across the table, and finally allowed to settle down upon it. The table is now slightly inclined, so that the mercury can drop off, and the plate settle firmly against the amalgam. When the mercury has ceased to run off, except very slowly, soft thick woolen cloths are spread over the plate, and weights are put on it, to press out all excess of mercury. At the same time the table is somewhat more sharply inclined. The weights may be removed in about thirty hours, as the amalgam will by this time adhere closely to the glass. The plate of glass is set up on edge, and a little more mercury will drop off. After about four weeks the mirror may be considered as finished.

If curved glass plates are to be made into mirrors, the amalgam is prepared by itself, and after spreading it as evenly as possible upon the plate, the latter is heated until the amalgam melts.

Great care must be taken to have the plates of glass perfectly clean, as the amalgam will only adhere to a bright surface. The cleansing is best performed by means of washing with strong soda lye. Since the process of making mirrors by the reduction of silver solutions upon the glass has been known, and can be quickly and cheaply carried out, the use of amalgam is falling more and more into disuse, a desirable condition in view of the fact that the work is very injurious to the health of the workmen employed, who must constantly breathe in the fumes of the mercury.

Amalgam for Electrical Machines.

This amalgam, known as Kienmayer's, consists of mercury 2 parts, tin 1, and zinc 1. The simplest method of preparation is to heat the mercury in a rubbing dish, and combine with it the other metals, previously converted into fine shavings, by continued kneading. To prevent the amalgam from becoming crystalline, a small quantity of tallow is added, and the mass kneaded until the tallow is completely combined with the amalgam. The amalgam will become crystalline in time, in spite of this precaution, and should be kept in a tightly closed glass vessel, and used within a few months.

Amalgam for Tinning.

Small articles of iron, as pins, for example, can be tinned by first making them bright by pickling in an acid, dipping in melted tin amalgam, blanching in dilute acid, drying and polishing.

Zinc Amalgam.

Zinc amalgamates readily with mercury, it being only necessary to heat the latter to the boiling point, and add the zinc in small pieces. Zinc amalgam is not employed directly, but is largely used in the zinc anodes of galvanic batteries. For this purpose it is prepared upon the zinc plate itself, by heating the latter to about 482 deg. to 500 deg. F., and dipping it at once into mercury, after first coating it quickly and uniformly with a solution of chloride of zinc and ammonia, applied with a brush. Amalgamation takes place immediately, and the plates thus treated give currents of greater strength and constancy than ordinary zinc plates.

Amalgam of Cadmium.

Cadmium combines with mercury without difficulty, forming an amalgam which readily becomes crystalline. The method of preparation of the actual cadmium amalgam, whose chemical composition is represented by the formula Cd, Hg_n, is the same as that of the other amalgams described; the mercury being heated nearly to boiling in a crucible, and the cadmium added in the form of thin sheets. Cadmium amalgam remains soft for some time, becoming crystalline only after a considerable period. The mass obtained by heating is therefore allowed to stand in the crucible until the excess of mercury separates out of its own accord; or it may be removed in the usual manner by pressing in a leather bag.

Pure cadmium amalgam is strongly crystalline, and forms a mass of a tin-white or silver-white color, which, on being moderately heated, softens, and can be worked like wax. It is used for filling teeth, either by itself, or compounded with other metals, which makes it still better for the purpose. The addition of tin or bismuth makes it more pliant in the heat, and for this reason the amalgams used for filling teeth are at present often composed of several metals. A few compositions are herewith given, but those containing lead are not recommended. Metals possessing such distinctly poisonous properties as lead and copper are liable to be attacked by organic acids even in an amalgam, and should never be used for filling teeth, especially as the harmless compounds of cadmium, tin, and bismuth answer the purpose perfectly.

	I.	II.	III.	IV.	V.
Cadmium	25.99	21.74	1	1 to 2	3
Mercury	74.01	78.26	..	..	..
Tin	....	....	2	2	4
Lead	....	....	..	7 to 8	15

The amalgam numbered I. corresponds to the centesimal composition of the combination of mercury and cadmium described above, and is very well adapted for filling teeth. After a time it becomes so hard that it can be worked with the lathe or file, and, of course, becomes hard in the mouth. Cadmium amalgams are very ductile, and can be used for many other purposes. An amalgam of equal parts of cadmium and mercury is extremely plastic, and can be stretched under the hammer like pure gold. It is silver-white in color, and not affected by the air.

Evans's Metallic Cement.

This alloy is prepared by dissolving the cadmium amalgam above described (25.99 parts of cadmium and 74.01 of mercury) in an excess of mercury, slightly pressing the solution in a leather bag and thoroughly kneading. If the amalgam is first heated to about 97 deg. F., and then kneaded, it becomes as plastic as wax, and can be shaped into any desired form. On cooling, it becomes quite hard, but does not equal in this respect the pure cadmium amalgam.

Amalgams of the Fusible Alloys.

The fusible alloys, previously mentioned in connection with the alloys of cadmium and bismuth, melt, in an amalgamated state, at a lower temperature than alone. By adding a suitable quantity of mercury, they can be well adapted to the purpose of filling teeth.

Amalgam of Lipowitz's Metal.

This amalgam is prepared by melting together 3 parts of cadmium, 4 of tin, 15 of bismuth, and 8 of lead, and adding to the melted mass 2 parts of mercury, previously heated to about 212 deg. F. Amalgamation will take place readily and smoothly. After putting in the mercury, the vessel should be removed from the fire, and the liquid mass stirred until it hardens. Lipowitz's alloy becomes soft at 140 deg. F., and melts at 158 deg.; this amalgam melts at about 143.5 deg. F. It is well adapted for the reproduction of objects of nature. Direct impressions of leaves and other delicate parts of plants have been obtained with it, which are not surpassed in sharpness of outline by the best plaster of Paris casts. The silver white color of the amalgam, and its fine luster, give it a pleasing appearance, and it is not affected by the air. It can be used for making small hollow statuettes and busts, which can afterward be gilded or bronzed by the process of electro-plating.

Small statuettes are easily made by preparing a hollow mold of plaster of Paris, heating it to about 140 deg. F., and pouring in the amalgam in a melted state. The mold is then swung to and fro so that the amalgam will strike all sides of it, and this is continued until the amalgam is cold. The mold is then taken apart and the seams trimmed with a sharp knife. If the work is skillfully done, the melted amalgam will fill out the finest lines of the mold, and no subsequent chiseling will be necessary. But some experience is required for this, and defective casts may be obtained at first, in which case it is only necessary to remelt the amalgam and repeat the process. A skilled workman will manipulate the mold in such a manner that all parts will be evenly moistened, and very thin but uniform casts obtained. The process may be modified by placing the mold upon a rapidly revolving disk, and pouring in the amalgam in a thin stream. The melted metal will be thrown against the sides of the mold by centrifugal force, and statuettes of considerable size can be cast in this way.

By the use of the revolving disk just mentioned, good results have been obtained with the fusible alloys, such as Lipowitz's and Wood's metal; and this process would seem to be especially well adapted to the manufacture of small objects of art, produced in such perfection in Paris and Vienna.

Iron Amalgam.

Iron has but little chemical affinity for mercury, and it is impossible to combine the two metals directly. An amalgam may be made indirectly by rubbing together very finely divided iron with mercuric chloride and water, and a few drops of metallic mercury. Pure iron amalgam forms lustrous white crystals, which, however, soon become coated with rust on exposure to the air, the iron being converted into ferric oxide, which floats upon the metallic mercury. Iron amalgam, in a pure state, has only a scientific interest, and is used in the industries only in the rare cases where iron is to be fire gilded. It is then produced upon the article itself, which is previously made bright by pickling, and then boiled in a mixture of mercury 12 parts, zinc 1, copperas 2, water 2, hydrochloric acid 1.5. Mercury is thus brought into solution, and separates upon the iron, forming a thin layer of iron amalgam upon the surface. The amalgam of gold can be easily and uniformly applied without further preparation of the article, and the subsequent treatment is the same as in ordinary fire gilding.

Bismuth Amalgam.

Mercury and bismuth can be very easily combined by melting the latter and introducing the mercury. The resulting amalgam is very thinly fluid, and can be used for filling out very delicate molds. An addition of bismuth also makes other amalgams more thinly fluid. Such combinations are cheaper than pure bismuth amalgam and frequently used.

Bismuth amalgams can be used for nearly all purposes for which cadmium amalgams are employed. On account of their fine luster, which equals that of silver, they are applied to special purposes, such as curved mirrors, and the preparation of anatomical specimens.

For silvering glass globes or spherical and curved mirrors the glass is heated carefully to the melting point of the amalgam, and a small quantity of the amalgam is poured into the cavity of the globe or convex mirror and this is swung to and fro until it shows a reflecting surface. If the amalgam is not intended to remain upon the glass, the surface is rubbed with olive oil before pouring it in, and the oil carefully wiped off. An extremely thin layer will remain, sufficient to prevent the amalgam from adhering. When it has cooled, it can be removed by gently striking the glass upon a soft surface. To make concave mirrors in this way, the glass is surrounded by an edge of thick paper, pasted upon the concave side of the glass, and then treated as in making convex mirrors.

If the work is properly done, the metallic surface will be perfectly bright, and will need no polishing; the trace of oil which adheres to it is removed by rubbing with ether or some other solvent. Sulphide of carbon should not, however, be used, as this liquid frequently contains small quantities of sulphur in solution, which would turn the white color of the mirror black. Mirrors prepared with bismuth amalgam acquire a yellowish tone after long exposure to the air, a phenomenon which is to be attributed to the formation of small quantities of sulphurous metals upon the surface of the mirror. They are at present little used, as curved mirrors can be more easily and cheaply prepared by the separation of silver upon them. If the very thin layer of silver which has been produced upon the surface is coated with copper by electroplating, or simply treated with a solution of asphalt in benzol, the mirror will retain its luster for an indefinite time, as the metal is perfectly protected from the access of air.

The bismuth amalgam for mirrors is made of bismuth 2 parts, lead 2, tin 2 and mercury 18.

Bismuth Amalgam for Anatomical Preparations.

Colored wax was formerly used exclusively by anatomists for injections into vessels. But a bismuth amalgam is far preferable for this use. It is silvery white in color and by becoming hard in cooling makes the preparation more solid. This amalgam melts at 169 deg. F., and remains liquid at 140 deg. F., the latter property making it especially useful for larger preparations. It is composed of bismuth 10 parts, lead 3.2, tin 3.5, mercury 2. For use, it is heated in a dish in a water bath to 212 deg. F., which insures its being forced by the injection pump into the finest ramifications of the vessels.

Sodium Amalgam.

Sodium amalgam is not used by itself, as it quickly decomposes in the air into caustic soda and mercury. But it can be employed in preparing many other amalgams which cannot be made directly.

If for instance, sodium amalgam is brought together with a solution of a metallic chloride, the other metal in the combination is usually separated from the chlor-

ine by the sodium, and at the moment of the separation unites with the mercury to form an amalgam, while the sodium combines with the chlorine. The presence of a very small quantity of sodium amalgam exerts a very favorable influence upon the formation of other amalgams, and by its use in the process of obtaining gold and silver by amalgamation, considerable time is saved and the amalgamation is more complete.

Sodium amalgam is prepared by melting sodium under petroleum and introducing the mercury through a very narrow glass tube. Both the metals combine at once, with a very peculiar noise, and the amalgam hardens to a silver white mass, which, however, must be kept under petroleum until it is to be used, to prevent the oxidation of the sodium.

If sodium amalgam is put into a solution of ammonium chloride, it swells to many times its first bulk, rises to the surface of the liquid, and is converted into amalgam of ammonium, which, however, is a very unstable compound, quickly decomposed into ammonia, hydrogen and metallic mercury on exposure to the air.

Other Amalgams.

Every metal is capable of forming an amalgam with mercury, but it is not necessary to mention these in detail, as none of them, other than the ones already described, is of any technical value. They are all prepared in a similar manner. Into the solution of the pure chloride of the metal in question is introduced a corresponding quantity of sodium amalgam. The sodium combines at once with the chlorine, and the liberated metal forms an amalgam with the mercury.

Many of these compounds have not as yet been thoroughly examined, and some of them, as for instance the amalgams of nickel, chromium, and cobalt, may yet take an important part in industry.—Translated from A. Krupp, Die Legierungen.

WITH THE BALTIC FLEET AT TSUSHIMA.*

By Lieut. R. D. White, United States Navy.

Introductory Note.—The following account is compiled from information obtained from one who was present at the battle. Having no station in battle he was selected to observe and record the events of the battle. This duty he performed with admirable care and accuracy. The times of the execution of certain maneuvers and the character of these maneuvers are indisputable. The range he recorded in each case was either measured by Barr and Stroud or was the range used by the twelve-inch guns at the time. The courses steered were recorded with care.

The value of his observations lies in the fact that he, being a close student of modern naval science, looked not for the spectacular in battle but for matters of technical interest—matters which bear on principles which govern in construction, maintenance, and tactics. I regret that I am unable to disclose his name. Let it suffice to say that his intelligence, his willingness to speak on the subject with honesty and without prejudice, his keen appreciation of the military strength and weaknesses of ships built and building, his power of observation in general and in detail, and his mastery of the principles of modern naval construction and warfare won my admiration and respect.

The statements made herein are in no case products of my imagination, but are his statements modified in construction and arrangement. I have merely attempted to bring out each fact, condition, and event that affected the final result and is of interest.

The morning of May 27, 1905, dawned raw and cheerless on the Baltic Fleet as it steered northeast for Tsushima Straits. A cold wind blew from the southwest penetrating to the very bones the Russian sailors, who, fresh from a tropical summer, huddled around the fire-room hatches or sought shelter in some favoring lee about the deck. A grayish mist hung chilly overhead and shut out clear vision well short of the horizon. When the rain fell later in the day it was cold and penetrant. Surely this was no day to inspire hope in the hopeless.

And a hopeless band it was. From the day of leaving Libau there had been nothing to augur good—nothing but toil, discomfort, and anxiety. No one had known what moment the fleet would be attacked. They felt sure that the Japanese were warned of every move on their part, while of the whereabouts of the enemy they could learn nothing. Rumors had placed it here, there, and everywhere; but reliable information could not be had. Just lately it seemed to have disappeared from the face of the earth, but they knew too well that it was sure to reappear. The question was, When, how? There was never a night after leaving Madagascar that did not bring the thought "tonight we shall be attacked by torpedo boats"; never a night that did not leave trace of its wearing vigilance on thought and spirit. And after all, what was the use of vigilance? As a result of their vigilance at the Dogger Bank they had been held up to the ridicule of the world. It was not a band to hope for victory. What they wanted was Vladivostock, safety, and rest.

Day was just breaking when the Russian leaders sighted one of the Japanese auxiliary cruisers looming vaguely through the fog. She remained in sight only a few seconds, then slipped silently out into the mist and all that remained to remind of her was a nervous clicking of the wireless instruments in a code that the Russians could not read. It was the message going straight to Admiral Togo telling that his days of waiting were at an end. In the Russian fleet was a ship especially fitted with a wireless set capable of sending messages six hundred miles. Why she did not break up this message and all future ones is a mystery, and the fact that she did not do so must ever stand as a monument to the inability of the Russian commander to accept modern conditions. Without interference, the Japanese scouts informed their commander, not only of the enemy's position, but its course, speed, and formation.

The next ship for the Russians to sight was the "Idzumo," which for two hours kept station abreast the Russian battleships on the starboard side. When she was somewhat within 8,000 yards Admiral Rodjestvenski ordered the after turret guns of all ships trained on her. Somewhat later a Japanese light cruiser squadron showed up on the port side; then a squadron of old battleships captured from China years before. This time all forward turrets were trained on the enemy, but as in the former case, the gunners were disappointed; the order to open fire never came. When one of the old battleships came within 6,400 yards a shot was fired from the "Orel." Whether the shot was caused by a mechanical accident, whether it was due to nervousness of some pointer, or whether the temptation was too strong to be resisted, is not known, but the natural result followed. Several other ships, thinking the Admiral had ordered it, opened fire. Admiral Rodjestvenski had not ordered it, however, and he soon signaled "cease firing," and further directed the fleet not to "expend ammunition to no purpose."

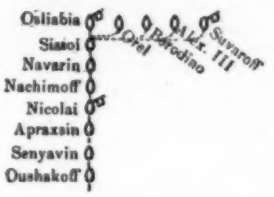
CRUISING FORMATION FORENOON OF MAY 27.

When sighted by the Japanese scouts, the Russian fleet was in two columns. The first division (the four new battleships), followed by some cruisers and auxiliaries, formed the right column. The second, Folkersham's, followed by the third, Nebogatoff's squadron, formed the left. Admiral Rodjestvenski's flag flew from the "Kniaz Suvaroff." Admiral Folkersham's from the "Osliabia," though that officer had died two days before. Admiral Nebogatoff's flag was on the "Nicolai," and Admiral Enquist's on the "Oleg." Scouts kept watch ahead and to either side and the whole armada steamed at about ten knots. During the forenoon one maneuver was executed. The speed of the first division was increased to eleven knots and with this superior speed the first division was placed at the head of the left column. It may be remarked that it took practically an hour to complete this evolution. The fleet now took up nine knots and this was the standard speed throughout the battle.

At noon the first division executed "column right," and when the last ship had made the turn executed "column left,"* regaining the formation they were in before; then, increasing the speed to eleven knots, the last ship of this division was brought abreast the leader of the left column and again nine knots was assumed. It was in this formation that the enemy was met.

At 1:25 P. M. the combined squadron of the Japanese was sighted a little on the starboard bow, twelve ships in line ahead, standing almost directly across the Russian course. It was not difficult to recognize them, for every detail of their shapes and rigs had been studied from pictures for months. The "Mikasa," flying the flag of Admiral Togo, led. Admiral Kamimura's flag flew from the "Idzuma." A third flag flew from the "Nisshin," whose, the Russians did not know. Their formation was faultless in its exactness. Each ship seemed chained to the next ahead; and even at that great distance the whole mass seemed to sweep with tremendous velocity across the sea. Their speed was only sixteen knots, but every Russian that watched would have called it twenty. It is a delusion that comes to all after a long trip at sea.

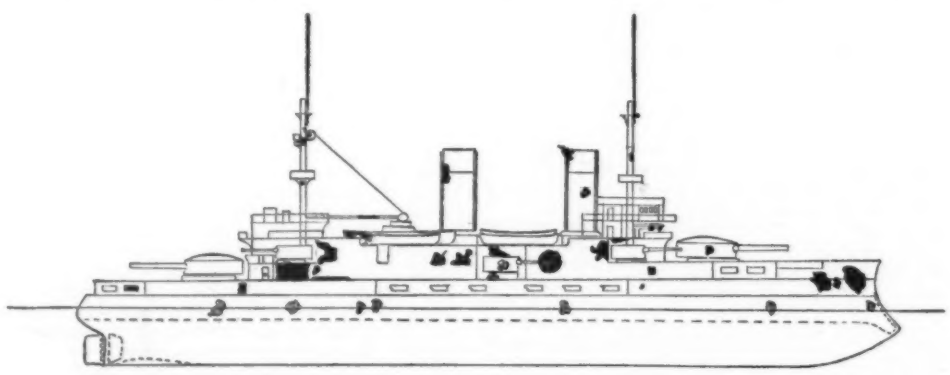
But there was little time to watch. The call to quarters brought all to their senses. There was plenty to do and surely that flying line of gray lent an inspiration to haste. If Admiral Rodjestvenski desired



the "L" formation in the first place he wished for it now with all his heart. He had to get his ships into column. That flying column would soon be on his flank. Something must be done and done quickly. The brilliant hour-long maneuver of the forenoon suggested itself to his mind. He would do it again. He ordered eleven knots for the first division and inclined the leader's course three points to port.*

This was at 1:38 P. M. The middle of the Japanese fleet was directly ahead of the "Suvaroff" and the distance, measured by Barr and Stroud, was 12,000 yards. As the Japanese column cleared the path of the Russians the course was changed to the southward till it became nearly directly opposite to the original course of the Russians; then, judging his time with beautiful exactness, Admiral Togo, at 1:55, countermarched and brought his entire fleet into action, opening fire on coming to 6,000 yards. As each ship made the turn she opened fire on the "Osliabia," which at that time was stopped and was an easy target, if a ship six thousand yards away may ever be called such.

The Russian initial maneuver proved disastrous. At the end of twelve minutes the "Suvaroff" changed course three points to starboard and resumed nine knots speed thinking the left column would follow in astern of the first division. As she changed course the "Suvaroff" opened fire and signaled, "fire on the leader of the Japanese column." The "Osliabia" also changed two points to starboard hoping to fall in astern of the "Orel," but she was too far ahead and had to stop to avert collision, thus throwing all ships astern of her into confusion. Unlucky "Osliabia"! Only three shots were fired from her forward turret. A shell struck the embrasure beneath one gun and, exploding, jammed the gun in extreme elevation and lifted the top of the turret. It will be remembered that the "Osliabia's" armor belt extends no farther forward than the forward turret; consequently when two high explosive shells struck on her water-line near the bow, they found soft spots. Each made a hole of tremendous size and the inrush of water brought her rapidly down by the head. Three more shot holes in the forward part let in more water and when water began to enter through the gun ports of her three-inch battery the port shutters were found bent and twisted and could not be closed. A twelve-inch shell struck an armor plate on her water-line amidships, loosening the bolts. A second shell striking the same plate caused it to fall off. A third shell striking where the plate had been, opened a tremendous hole in her side and her doom was sealed. She left the line with her forecastle completely submerged, the water filling her holds with a roar, but as she turned she fired a parting shot from her after turret, a token of undying spirit—a fling of defiance to the detested "monkeys." For a while she lay on her side,



her funnels just clear of the water; then slowly capsizing, she sank at 2:52 P. M. A torpedo boat went to the rescue but was unable to save more than a small part of her crew.

As the Japanese battleships passed ahead of the "Osliabia" she was left to the care of the armored cruiser squadron and their fire was concentrated on the leader of the column, the "Suvaroff." At 2:05 the

* Reprinted from the Proceedings of the Naval Institute.

* Officers on the staff of Admiral Rodjestvenski claimed after the battle that the signal made for the second step of this maneuver was "ships left," which would have made the formation an "L" in shape, but inasmuch as the three ships executed "column left" without hesitation, and since the fleet subsequently steamed in the new formation for an hour without any attempt being made to correct the error, it can hardly be believed that the formation taken was the result of a mistaken signal.

* As to discrepancies that appear in recorded times, it must be explained that at noon the time on Admiral Rodjestvenski's flagship was set ahead thirty minutes without signal to the rest of the fleet. The remainder of the fleet retained the old time, which was about twelve minutes slow on Japanese time. Certain events are recorded as occurring at the moment it was observed that they had occurred, and the times were sometimes simply estimated. The times quoted here are those of the Russian fleet exclusive of the Suvaroff.

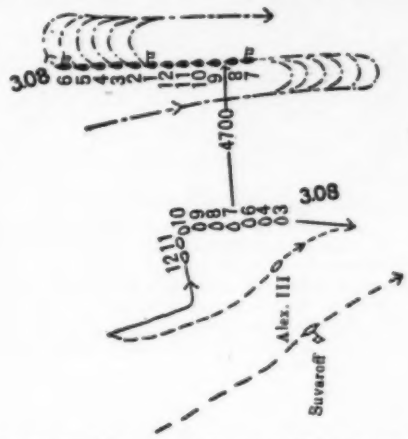
"Suvaroff" began to suffer terribly from the fire and changed course four points to starboard, hoping the Japanese could lose the range, then 5,000 yards. Seven minutes later she reverted to her old course. The effect of this maneuver was disconcerting principally to her own gunners. The old maxim, "It is more dangerous to run away than to charge" seems proven. On August 10, the year before, when the "Retvisan" charged the Japanese line she was hardly hit at all. All the shots went over her. This day as the "Suvaroff" ran she received her worst hurt. The effect of this concentrated fire on the "Suvaroff" is indescribable. There was literally a rain of shells upon her. The lieutenant commanding the forward turret was struck in the neck by a flying fragment which almost severed his head from his trunk. As he was carried below another shell struck him, practically cutting his body in two. Early in the action a shell entered the embrasure in the forward turret exploding and igniting several bags of powder. The roof was blown completely off and landed on deck, leaning against the turret. The conning-tower was hit repeatedly. Admiral Rodjestvenski was wounded in the head by a fragment and rendered unconscious. All the plating above the armor belt forward was shot away nearly as far aft as the turret, causing her to resemble a monitor. A fire burning on her quarter-deck caused the plating to settle, cutting off access to the compartment just below the upper armor deck which was used for an operating room. At 2:25 she left the line, ablaze fore and aft, unable to withstand longer the terrific bombardment. Even then she was not entirely secure; she was doomed to receive further punishment later.

The "Alexander III." led the column after the "Suvaroff" fell out and she in turn received the fire of the entire Japanese fleet, which by this time had drawn ahead until the tactical advantage was tremendous (see position of fleets at 2:30). The whole fleet could concentrate on the leader of the Russian column with a range varying only from 5,100 to 5,600 yards while the rear ships of the Russian column were completely out of range. In addition to this the brown powder used in the big guns of the "Navarin," "Nachimoff," and "Nicolai" enveloped themselves and the ships astern of them in smoke and restricted their fire. To drive on in the face of these odds meant certain destruction for the "Alexander III." At 2:30 she turned east, the ships astern following in their turn. While this maneuver relieved her for the moment, each of the next few ships as it turned the knuckle received the full effect of the Japanese fire.

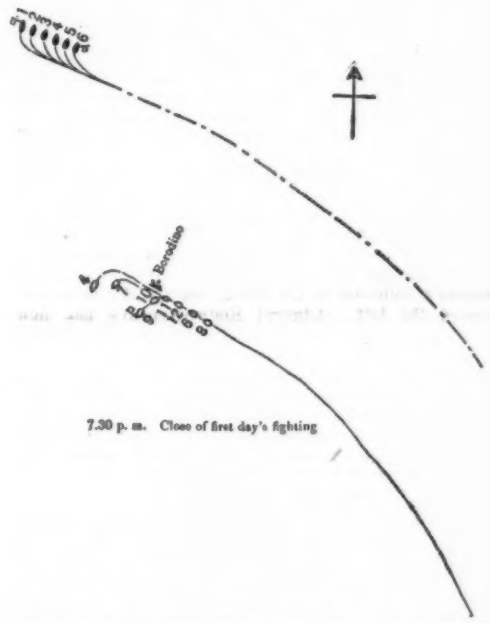
The fog at this time seemed to thicken and this with the smoke from the burning Russian ships practically hid them from the view of the Japanese. When a ship could be made out the Japanese fired on it, but there was no concentration of fire at this time.

The number of fires that broke out on board the Russian ships about this time is remarkable, considering the fact that woodwork was limited in accordance with modern theory, especially in the construction of the four new battleships. Thirty-four different fires broke out on the "Orel" during the day. There were three different fires in the hammocks stowed just forward of the bridge, the smoke in each case driving all occupants from the conning-tower. Hawsers caught fire easily and were difficult to extinguish. The smoke from one burning abaft the forward bridge once more drove all hands from the conning-tower. Being confined by the boats on the skids the smoke was drawn into the forward fire-room by the blowers and this compartment had to be abandoned. It filled the port forward 6-inch turret with smoke which penetrated to the lower decks; and there the crew, believing that an explosion had taken place in the turret and that the fire was spreading to the magazine, abandoned their stations and were just beginning to flood the magazine when the turret officer, attracted below by the failure in ammunition supply, saw and arrested the act. Whenever a shell struck armor plate bits of burning paint flew in every direction, most dangerous to exposed persons; and at 2:40, when the "Alexander III." fell out, her whole side was ablaze. It was the war-paint burning, and the blaze was not extinguished till the greater part of it was burned off. The red lead beneath the war-paint did not burn, however, and she came out of the fire as red as if she had been freshly leaded.

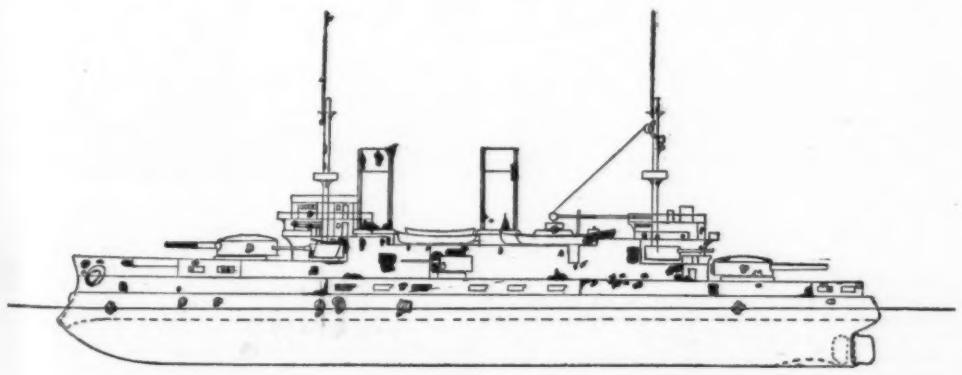
The "Borodino" now led the column, continuing to the eastward. The gray color of the Japanese fleet was so well in keeping with the grayish fog that they were scarcely discernible from the Russian position. Their whereabouts were followed principally by the flashes of the guns as they fired. They had drawn well ahead. Even the last ship of the Japanese column was ahead of the Russian leader, and in the fog the way of escape to the rear of the Japanese column



was most inviting. At 2:50 the "Borodino" put her helm to starboard and ran to the northward, the ships astern following in turn. If the Russians had counted on escaping unobserved they had failed to consider the glaring yellow color of their smoke pipes, which stood out like beacons in the fog. The Japanese had seen the movement as soon as it commenced and two minutes later the six ships of their main squadron swung in unison left about and advanced in pursuit. The armored cruiser squadron, passing inside, duplicated the maneuver and followed the main squadron.



At 2:58 the captain of the "Borodino," seeing the possibility of being caught with the whole Japanese fleet athwart his bow, turned to the eastward once more, and the fleets passed each other steaming in opposite directions. The "Orel" was selected as the principal target. In six minutes she was struck twelve times with 12-inch shells and thirty or forty times with 6 and 8 inch shells. To realize the terrific effect of this shelling one must consider that a shell filled with Shimose powder is really a small torpedo; that each 12-inch shell striking an unarmored portion and exploding made a hole seven feet high and six feet wide; that the fragments of these shells were minute particles that filled the air like driving mist; and that a dense black smoke settled down after each explosion blinding and suffocating all in the vicinity. The decks of the "Orel" were surely no playground at that juncture. One sailor is known to have been struck one hundred and thirty times by fragments from a single shell. A single shell, entering a gun port on the "Sissoi Veliki," set fire to the paint and she left the line at 3:20, one whole side of her battery deck ablaze. After extinguishing the fire she fell in again at the end of the column.



At 3:19 the Japanese main squadron executed "ships right about," and the cruisers after passing did the same thing, bringing the fleet into its original formation, steaming to the eastward.

The "Alexander III." resumed her position as leader of the Russian column while the fleets were steaming in opposite directions, and as the Japanese advanced to the eastward she gradually eased off to the southward till 3:40, when she again headed east.

At 3:30 the "Suvaroff," which had been steaming to the eastward at about seven knots, broke through the Russian column apparently unmanageable, passing astern of the "Apraxsin." She was easily recognized by the ships near by, but appearing thus toward the Japanese line, and with only one mast and one funnel standing, she was mistaken by the Russian ships near the head of the column for one of the "Matsushima" class, and was fired on by them. At 3:40 she was attacked by the Hirose flotilla but these boats were easily driven off by the Russian ships near by. Then, as the Japanese fleet swung by, she was subjected once more to their concentrated fire. Thus battered by friend and foe she staggered back across the Russian line an utter wreck, only to be fired at once more by Russian guns. It is safe to say that not more than one of her guns could work effectually when Suzuki's flotilla found her at 4:45. In this practically defenseless state this flotilla, and another under Fujimoto, succeeded in striking her four times with torpedoes and she sank; but not until 7:10 P. M.—a record that speaks well for her design and builders.

(To be continued.)

[Continued from SUPPLEMENT No. 1590, page 25471.]

TINNING.—II.

POLISHING THE SHEETS.

FOR some purposes, where it is desirable that the tin plate should have a fine appearance and a high luster, the sheet iron, before tinning, is passed between rollers, called polishing rollers, and with this one manipulation, the tin coating, on the perfectly smooth surface, will usually be bright enough. If this is not the case, the finished sheets, before being polished with chalk, are passed between smooth rollers, under strong pressure, and acquire in this way, with the chalk polishing in addition, such a brilliant reflecting surface that they may actually be used for mirrors.

The German method of tinning is very well adapted for giving a coating of tin to utensils made from sheet iron by stamping or pressing. To do this, the articles are pickled, just as in the case of the sheets, scoured with sand and immersed in a tin bath, which has a film of zinc chloride floating on top. The bath is of ordinary, impure tin, warmed to 509 deg. to 518 deg. F., thus about 86 deg. to 95 deg. above the melting point of tin. The leavings of previous tinning operations are generally utilized for this purpose.

The articles are left in the first bath for five or six minutes, then brushed with a scratch brush to remove any little balls or knobs of tin, dipped into pure tin, brushed again, and completed by a third dipping into pure tin.

The heating may spread the seams of vessels made of several pieces, and such must be tested in water; if they leak, the seams are closed with pure tin applied with a soldering tool.

THE MECHANICAL METHOD OF TINNING.

The process of tinning, as performed by hand, is laborious, and necessarily imperfect, because lacking, to a certain degree, in uniformity; and many inventions have been made with a view to substituting machine work. Pickling and scouring machines have been constructed, and mechanical contrivances for putting the sheet through the tin baths. It is, in fact, not very difficult to construct apparatus, with the aid of which almost all the processes of tinning can be satisfactorily accomplished without recourse to hand labor, always slow and therefore laborious.

Pickling Machines.—The pickling of the sheet iron is very effectually done by an apparatus consisting of a wooden trough about 13 feet long, and two rollers. The trough holds the pickling fluid, dilute sulphuric acid. One of the rollers inside it is even with the top, the other one is set lower down. Over both are adjusted cylindrical rubber bands, in such a way that when one roller is set in motion the other is turned by friction. Tightly-stretched hempen cords may be used in place of the rubber, but are not as good.

The sheets to be pickled are laid upon the lower roller, and this is made to revolve in such a way that they are moved by the bands toward the upper roller. If the acid bath is strong (1 : 2) one revolution of the roller is enough to pickle the sheets perfectly. From the upper roller they are slid on to an arrangement of rubber bands stretched over horizontal rollers, and carried away, to be cleansed from adhering acid by having water dashed over both sides; or else they are dropped into a large vessel filled with water.

Tinning Machines.—The tinning apparatus constructed by Girard is on the same principle as the pickling machine, the sheets being carried through the bath by a mechanical arrangement. The accompanying illustration shows the construction. The tin is in a shallow pan, *P*, made of cast iron or heavy boiler plate, with an uneven bottom, as seen in the drawing. A vessel, *C*, in the form of a quarter cylinder divides the pan, filled to the height shown with melted tin, into two parts.

Girard's method is to have the tin in the left-hand division covered with zinc chloride, that in the right-hand one with rosin, but zinc chloride may equally well be used for both, as it perfectly fulfills the desired purpose, that of preventing the oxidation of the tin. The tin in the left-hand division, as may be seen from the location of the fire, is more strongly heated than that in the other, since the former is exposed to the direct flame, the latter only to the heated gases.

In the left-hand side of the pan are a number of bent iron rods, *P*, which direct the immersed sheets and carry them under *C*, between the rollers, *W*. These rollers can be brought nearer to each other by the screw, *S*, and are joined outside the pan by cog wheels, so that they move in opposite directions.

The working of the machine is very simple. A sheet is slipped over the directing rod, *P*, into the melted tin, left until the first coating has formed, then pushed by an iron rod against the rollers, *W*, forced between them by their motion, and lifted out of the pan. The process is repeated until the tin coating is sufficiently thick.

Girard's apparatus has several very material advantages; the work is carried on quickly and uniformly, the edges of the sheets are not more heavily tinned than the rest of the surface, and the amount of tin used is less than in the previously described methods.

Means of Protecting the Tin.—In regard to the substances used to prevent the surface of the tin from oxidizing, various methods have recently been proposed, whose object is to dispense with fats, which are expensive and which give off troublesome products in decomposition, and to provide suitable substitutes. Zinc chloride or ammonio-chloride of zinc, or a mixture of zinc chloride (86 per cent) common salt (10 per cent) and tin salt (4 per cent) are recommended.

Zinc chloride, which works excellently in every respect, is produced by bringing together hydrochloric acid and an excess of zinc in the form of chips (zinc waste) and leaving these in contact until there is no longer any evolution of gases. The liquid is filtered off clear, concentrated to the thickness of syrup, and used in this state.

The concentrated solution of zinc chloride obtained

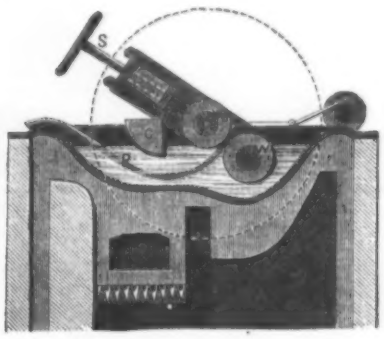


FIG. 1.

in this way can be heated very strongly without any fear of the gases and fumes so disagreeably evident in the case of fats. The only precaution to be observed is to prevent the liquid from coming in contact with the skin, as it is extremely caustic in its action. Ammonio-chloride of zinc is obtained by dissolving ammonium chloride (sal-ammoniac) in the liquid resulting from the treatment of zinc with hydrochloric acid, and evaporating to the consistency of syrup.

MOIRÉ PLATE.

In describing the general properties of tin, its strongly crystalline character has been mentioned. This property can be taken advantage of to produce very pretty designs upon tin plate, resembling frostwork. Such tin plate is called "moiré" or "moiré metallique." The most beautiful moiré (watered) plate can be made only from sheet which has cooled very slowly after tinning, because in this case alone are formed large and long crystal needles in the tin. Sheet which has cooled quickly can also be made into moiré, but will be of no especial beauty, as the crystals will be small and irregularly arranged.

The finest effect is obtained when the tin upon the surface of the plate is partially melted and allowed to cool more or less slowly, according to the nature of the design to be produced. The more quickly the molten tin hardens, the smaller will be the crystals, and the greater the resemblance of the finished surface to mother-of-pearl. The design may be beautifully brought out by melting the tin at certain places, at a distance from each other. If a red-hot soldering tool is passed over the surface, and figures or letters sketched with it, they will appear plainly after the subsequent pickling, traced by the shrinking together of the crystals. If the whole surface is to have the appearance of moiré, it is held over a coal fire until the coating is melted, and then either cooled slowly in the air, or suddenly by being thrown into water, according as it is desired to have larger or smaller crystalline figures.

The figures do not appear plainly until the plate is pickled, and highly-diluted hydrochloric or nitric acid is used for this purpose. The plate is laid in the acid, and left until the design is clear, then quickly rinsed in water and dipped into boiling water; on being removed from the latter all moisture evaporates in a moment, and the plate is coated immediately with a transparent varnish, colored or colorless, as desired, to preserve the beautiful luster, which would be injured by air.

According to the method of Böttger, the plates are heated to the melting point of tin, and thrown into a liquid consisting of 4 parts of water, 1 of nitric acid, 2 of hydrochloric acid, and 2 of tin salt, which brings out the designs with great clearness.

For the varnish, solutions of bleached shellac in the strongest alcohol, or volatile copal varnish, are used; and these can be colored red with fuchsin, violet with methyl violet, blue with aniline blue, green with iodine green, or yellow with picric acid. The combination of the design, the metallic luster, and vivid color give articles made from such moiré plate a beautiful appearance.

TINNING OF WIRE AND WIRE GAUZE.

To tin iron wire, it is run slowly through a wooden trough containing three volumes of water to 1 or 1½ of hydrochloric acid, rinsed in water, dried by passing through rollers covered with felt or coarse woolen cloth, and then carried under a roller turning easily in a vessel holding strongly-heated tin. The wire can be subsequently polished between wool-covered rollers dusted with powdered chalk.

Wire gauze is pickled in the same way. The adhering moisture is wiped off with cloths, the wire is dusted over, by means of a dust-bag, with finely pulverized rosin, stretched upon a frame and immersed in the tin bath, where it is left for one or two minutes, lifted out and freed from superfluous tin by a quick blow upon the frame.

An especially fine tin coating upon iron wire is obtained by the following method: The wire is laid into a wooden trough of suitable size, containing water mixed with 10 per cent of hydrochloric acid. Upon the bottom of the trough are laid plates of zinc. After a little time, a gray coating of zinc will have formed upon the wire, and it is then put into the tin bath, prepared by putting 2 parts of tin salt into a linen bag and suspending this in a vessel containing a solution of 2 parts of tartaric acid in 100 parts of water. After the salt is dissolved, the liquid is stirred until the white precipitate formed is dissolved, and 3 parts of soda, in solution, are added a little at a time. The liquid will foam up vigorously, on account of the formation of carbonic acid, and deposit a white precipitate. It is left standing until perfectly clear, and then drawn off. The wire, joined to zinc plates, is left in the bath two or three hours. A dull white, very uniform tin coating will be formed upon the wire, and once passing it through a wire-drawing plate will give a fine luster and make the tin adhere very closely. Gauze made of such wire has a fine appearance, and wire rope from it is very durable, since it will not rust.

To insure a very smooth, bright, and durable coating, the drawing of the wire must receive special attention. It should be done in such a way that the soft tin coating is simply pressed closely to the wire, without stretching the latter. Tinned wire which is to be used for wire gauze or for sieves may be gently pressed to flatness between polished steel rollers; this will smooth the tin coating and make it adhere very closely.

TINNING OF CAST IRON.

The tinning of cast iron requires a special process. The carbon contained in it makes the adherence of the tin difficult, and the work must be directed to the end of decarbonizing the surface by chemical means, or of keeping the metal absolutely bright by mechanical treatment.

The surface can be partially decarbonized by enveloping the objects in substances which give off oxygen when heated, and thus oxidize the carbon. Ferric oxide or manganic oxide (brownstone) is generally used for the purpose. These substances, in powdered form, are put around the articles, which are then incased in fireproof clay, and kept at red heat for five or six hours. The iron is so far decarbonized by this treatment that it will take in the tin without difficulty.

The heating is followed by picking with dilute sulphuric acid, to which are added small quantities of blue vitriol, tin salt, or glucose, to prevent too much of the metallic surface itself from being dissolved, as well as the layer of oxide. The subsequent tinning is done in the usual way, by immersing the whole object in melted tin; or, if only the inside is to be tinned, by pouring into it tin wth ammonium chloride or ammonio-chloride of zinc, and quickly rubbing this into the surface. It is well to warm the metal before applying the tin, but not so much as to bring out any tempering color, caused by oxide, which would hinder the adherence of the tin. The objects, when finished, are placed in water to cool, with the inside downward; but they must be immersed in such a way that the tinned surface does not come in contact with the water, but is protected by the air inclosed in the vessel.

In the other method the decarbonization process is dispensed with; the vessels are rough-turned on the inside, polished with sandstone, pickled with sulphuric acid, and dried. At the present time, the art of enameling iron has been carried so far that it is possible to enamel even very large articles, and the tinning of cast iron has therefore fallen into disuse. Cast iron rods, etc., can be quickly and easily tinned by pickling, rinsing with water, dipping into a solution of 1 part of ammonium chloride in 16 of water, drying, warming, and immersing in strongly-heated tin.

A method of tinning recommended by Barthel and J. C. J. Möller is to first give a coating of pure tin by means of the galvanic current, then to apply a solution of zinc chloride, and finally dip into the melted tin. This method, simple in itself, is complicated by the fact that it requires a galvanic battery, and would hardly be profitable unless a large number of articles were to be treated.

Nails, hooks, and other small articles are tinned by putting them into a spherical vessel, adjusted so as to revolve, and placed over a fire. Liquid tin is poured in, and ammonium chloride scattered over it, and the vessel is kept in motion for a while. To prevent the tinned articles from adhering to each other, or having drops of tin left upon them, they are put, while hot, through a succession of two or three sieves, kept in a shaking motion, and finally dropped into water. Unless previously pickled, the tin coating would not adhere to all parts even of these small articles, and it is well to pickle them for a short time, rinse with water, heat with ammonium chloride, and tin them after this has dried.

An especially fine tin coating for such small articles is obtained by the same treatment as that given to small brass and copper articles, which will be described later.

Iron can be more easily tinned if it is first given a light coating of copper. This can be done by immersing the objects, polished bright, in a boiling solution of zinc chloride, where they receive a coating of zinc, and then in copper melted under a cover of borax. They will be lightly coppered in a short time, and the melted tin will easily adhere to this coating while hot, using ammonium chloride.—Translated from the German of Friedrich Hartmann in "Verzinnen, Verzinken, Vernickeln, Verstahlen," etc.

HOW TIDES ARE PREDICTED.*

By PROF. WILLIAM H. HALLOCK, of Columbia University.

IT was Sir Isaac Newton, in his "Principia," who first set forth the true cause of these wonderful disturbances in the calm depths of the ocean. Men like Bernouilli and Laplace advanced the mathematical theory of the subject, but to-day the man who is entitled to the last word upon this most complex and important subject is Sir George Howard Darwin, K. C. B., F. R. S., Plumian Professor and Fellow of Trinity College, Cambridge.

If one refers to Sir George's articles on the tides in the Encyclopedia Britannica or to his papers in the Proceedings of the Royal Philosophical Society the

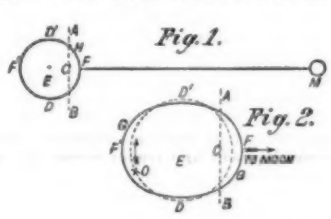


Fig. 1.

Fig. 2.

bristling array of the most complicated mathematical formulæ makes it seem easier to decipher the hieroglyphics of Egypt than to attempt to get any simple conception of this every-day phenomenon. And yet he has accomplished a most difficult task, which is, as he so aptly states it, "to shell away the apparatus of investigation and the technical mode of speech from the thing behind it."

Even in a seaport like New York it is safe to say that not one in a thousand realizes the importance of the tides, their causes and peculiarities. They go up hill onto a ferryboat this morning and down hill a few days later without thinking of it. Many and amusing theories have been devised to account for the tides, and although their apparent connection with the moon was recognized even by the Romans, nevertheless people have not yet ceased to evolve new theories as to the cause of this connection.

The Newtonian theory holds the field against all others. We have often seen two children taking hold of each other's hands swing round and round, neither going simply around the other, but both around an axis somewhere between them. If one child is larger than the other, then she moves around in a smaller circle, and if a grown man thus swings a small child by its hands he seems to move very little, compared with the movement of the child, and yet it is evident that he does swing a little to counterbalance the pull of the child.

If we imagine that *M* in Fig. 1 is a small ball, and that *E* is a large one, the two held upon a long, light, stiff bar *FM*, then it will be possible to find some point as *H*, such that, if a string is attached at that point, the two balls will balance with the connecting bar horizontal. If the balls were of equal weight this point of suspension would be in the middle of the bar. If we carefully begin twisting the supporting string the system will be set in rotation around the axis *AB*, passing through *C* the common center of gravity. *M* will travel in a circle of radius *CM* and *E* in a circle of radius *CE*. The centrifugal force pulling out on *M* being just counterbalanced by the corresponding force on *E* directed in the opposite direction, such a system would resemble the case of the man and the child.

If we consider *M* to be the moon and *E* the earth and replace the connecting bar by the attraction of gravitation acting to hold them together, we have a diagram illustrating the conditions as they really exist in nature. We always speak of the moon as revolving around the earth, when in reality they both revolve around a common center of gravity. The earth is about eighty times as heavy as the moon,

* From the New York Times.

consequently *CE* is only one-eighteenth of *CM*. The mutual attraction of the earth and moon holds them together, and they revolve at such a rate that the centrifugal force tending to throw them apart is just balanced by the force of gravity tending to make them fall together.

Let us analyze a little more in detail the effects of these forces upon the earth. It is the pull of the moon upon the earth as a whole which preserves the balance, and for purposes of discussing this balance of forces we could have assumed that all the mass of the earth were concentrated at its center, *C*. Thus the mutual attraction just balances centrifugal force at *C*. Consequently a part of the earth situated at F^1 being further from *M* will be pulled less by gravitation, and the centrifugal force would overbalance, and any object at that point would tend to leave the earth. On the other hand, at *F*, being nearer to *M* than is *E*, the centrifugal force would be less and the attraction greater, hence the attraction will overbalance the centrifugal force, and an object at *F* would also tend to leave the earth. Thus if *E* were an elastic sphere it would bulge out at F^1 and *F* and be drawn in at D^1 and *D* in a plane at right angles to the direction *EM*. If *E* were a solid sphere with a thin coating of liquid, then the liquid would be piled up at F^1 and at *F*, while it would be drawn away from *D* and D^1. It would be high tide at *F* and F^1 and low tide at *D* and D^1.

The ellipse in Fig. 2 may serve to illustrate in a very much exaggerated way the shape of the surface of the liquid. Similarly our ocean is always tending to pile up at a point under the moon and at the antipodal point thereto. As the earth revolves upon its axis a point, as at *O*, Fig. 2, will pass in succession through points of high and low tides, having two high tides at *F* and F^1, and two low tides at *D* and D^1 in every complete revolution of the earth—that is, every twenty-four hours, or, to speak more correctly, every twenty-three hours, about, for the forward motion of the moon in its orbit is continually shifting the direction of the pull.

Such would be the simple case if the moon alone were concerned and the "tidal wave" had free sweep around the earth. All this beautiful simplicity vanishes when we pass to the actual conditions upon the earth. The tidal wave would lag a little behind, even if there were no continents, so that the motion of the earth on its axis would carry the high tides a little forward toward *G* and G^1; the moon, trying to hold back this wave to its ideal position, produces what is known as "tidal friction," which is tending to slow up the axial rotation of the earth and lengthen our day.

Of course, in reality these tidal waves never attain anything approximating ideal development. They may start their development and travel across the Atlantic, only to encounter the coast of America and be broken up and reflected back. They travel up the bays and rivers, producing the most interesting results. Between New York and Albany there are two whole tidal waves in the Hudson. In the Bay of Fundy the tidal wave is concentrated, like a sound wave in an ear trumpet, until it rises to great heights.

So far one might imagine that it would be a very simple affair to predict the tides. Not so very long ago it was a valuable family secret to be able to predict the tides. Notably the Liverpool tidal tables were a family monopoly for several generations. A rather careful analysis of a long series of observations enabled those initiated into the secret process to calculate for the future.

When it is remembered that the mutual attraction of the earth and the sun gives rise to a similar tidal wave the possibilities of complications become apparent. The solar tidal wave is smaller than the lunar wave, for the much greater distance between the sun and the earth makes the differential action on the two sides of the earth much less. At new moon, when the moon and sun are in the same direction from the earth, and when, at full moon, they are opposite, the solar and lunar tidal waves combine to make a "high run of tides," "spring tides," but when, at first and third quarter, the sun is in the direction *D* D^1, then the two waves tend to neutralize each other. Bearing in mind the fact that the orbit of the moon is inclined to the orbit of the earth, and that the distances from the earth to the sun and to the moon vary at different seasons, it will be seen that the problem of prediction becomes no simple matter, and, further complicated by continents, it would seem well-nigh impossible. Nevertheless, tidal tables are computed, and check with observation with remarkable accuracy.

These same tidal forces which deform the liquid envelope of the oceans act similarly upon the "solid" nucleus, and Lord Kelvin computed that the mass of the earth must be at least as rigid as ordinary steel to be able to resist these tidal strains. If the earth really possessed a semi-liquid center, as was believed at one time, there would be a tidal wave in it, which would buckle up the surface of the earth twice a day. Now we know that the interior of the earth is kept solid by the enormous pressure of the strata themselves. Nevertheless, these tidal strains are active, and may well be the last straw which breaks loose the forces evinced in many an earthquake.

A moment's reflection will bring out the enormous importance of the most exact knowledge of the tides and tidal currents. The mariner must calculate his position at sea in very many cases by "dead reckoning," from his speed, the time, etc., and many a vessel has gone to destruction because the "set of the tide" was not known or was temporarily changed by storms. We can almost imagine that old Ocean is taking particular pride in wafting to our shores upon its proud flood the man who has studied the beating of its heart most successfully.

SCIENCE NOTES.

Dr. H. Erdmann has recently investigated the properties of liquid nitrogen more fully than had previously been done. It is a clear, mobile, colorless liquid which differs greatly from liquid air in its physical properties. It produces a much greater lowering of temperature on evaporation, and is thus a good cooling agent. When it is poured over a bulb of oxygen the gas condenses in bluish drops on the inside of the glass. Liquid nitrogen is a good solvent for liquids that boil at a low temperature. It mixes readily with liquid ozone. As a chemical agent it is as indifferent as gaseous nitrogen, and burning magnesium wire plunged into it is immediately extinguished. When poured over metallic calcium, however, it enters into combination to form calcium nitride, which yields ammonia on treatment with water.

The phonograph is being diverted to valuable scientific account in Great Britain in preserving records of rapidly-decaying dialects of the Isle of Man and Guernsey. In the former island the dialect language is one of the Gaelic group, and so rapidly is it disappearing, that it is anticipated that it will become extinct during the present generation. The Manx Language Society is dispatching phonographs to remote parts of the island, the aged inhabitants of which still retain a pure accent, and the numerous records thereby obtained are to be preserved. In Guernsey the dialect is the old Norman French, and in its main features is exactly the same as that which was used by the cultured class in England in the early centuries. In this instance the phonograph is to be utilized for the collection of the dialect poems, folk songs, and folk lore of the island.

An interesting collection was recently disposed of in London by the sale of the extensive collection of lamps and other illuminating devices belonging to a well-known collector of domestic appliances. This collection was of value, since the owner had succeeded in gathering together a practical history of the lamp and its evolution from early times until the present day. It comprised a large series of lamps, showing the methods attempted by various inventors in getting the oil to the wick, and a unique selection of candlesticks and rush-holders. There was also a specimen of the ancient open terra-cotta lamp used by the Romans, several candlesticks used by the natives of New Guinea, comprising holders made of crude wood, and palm-oil rushlights, and a storm petrel with string wick from St. Kilda. He also possessed one of the first boxes of lucifer matches made, the box containing thirty matches and the small piece of sandpaper upon which the matches were ignited.

According to M. de Varigny, the Swiss scientist who has been engaged upon prolonged investigation of the movement of the mountain peaks of the Alps, there is a continuous change taking place in the altitudes of these mountains, especially of the Swiss and Austrian ranges. He points out that there are many villages in the canton of Valais, and the Bernese Oberland, that have been raised or lowered from twelve to thirty feet during the past six years, and that many of the mountains have also been subjected to the same action. The chief causes of this phenomenon he attributes to the constantly occurring though practically imperceptible earthquakes, to which tremors is also due the ever-increasing number of avalanches. As a result of his investigations, he finds that an ordinary atlas two years old is quite out of date as regards the heights and altitudes of the mountains and the Alpine villages.

According to Prof. Wiegand, of Cornell University, it seems probable that frost causes the death of vegetation by causing the actual withdrawal of water to form ice *outside the cell*. The ice formation dries out the cells, and the plant suffers therefore from drought conditions. Every plant cell has its critical point, the withdrawal of water beyond which will cause the death of the cell, whether by ordinary evaporation or other means. It may be supposed that the delicate structure of the protoplasm necessary to constitute living matter can no longer sustain itself when too many molecules of water are removed from its support. In the great majority of plants this point lies so high that it is passed very soon after ice begins to form in the intercellular spaces. Hence the death of so many plants at this point. But other plant cells may be able to exist with so little water that a very low temperature is necessary before a sufficient quantity is abstracted to cause death. From some plants enough water cannot be abstracted by cold to kill them (many bacteria, it will be remembered, can endure the cold of liquid air). In rather dry tissues, as in some winter buds, a temperature twenty to thirty degrees below freezing may be required before the ice crystals can be seen in the tissue.

The Committee of Bibliography and of Astronomical Sciences of the Royal Observatory of Belgium has undertaken to publish a list of the observatories and astronomers of the whole world. A request for information, in the form of a list of questions, with a model reply relating to the astronomical service at the Uccle Observatory, Belgium, has been addressed to all the directors of observatories. In addition the list will include such astronomers (university professors, amateurs, etc.) as are not attached to any observatory, but are nevertheless actively engaged in astronomical research. The information already sent will enable the committee to draw up not only a list of observatories, with their geographical co-ordinates and the members of the staff, but also a table showing the astronomical activity of the whole world, thanks to the facts given as to the instruments at the disposal of each institution, the pieces of research undertaken, and the papers published. The directors of those observatories who have not received the question form, or who have not yet forwarded a reply, as well as unattached astronomers, should send the information desired to the chairman of the committee, Prof. P. Stroobant, astronomer at the Royal Observatory of Belgium, Uccle, Belgium.

It is with reference to the effects of external conditions upon the production of sexual and asexual fruiting organs that unusual progress has been made. In this direction a field of great magnitude has been opened by the work of Klebs, and it is evidently being pursued along all possible lines. As yet this work has been extended only to a few green algæ (as, for example, *Hydrodictyon* and *Vaucheria*); several fungi (*Sporodinia grandis* and *Saprolegnia nixtra* especially); certain yeasts and bacteria, and finally, to several species of phanerogams. While with the algæ the light relation is of prevailing importance, with the fungi it is more particularly a matter of nutrition or transpiration. As a rule, with the latter Klebs finds the stimulus to reproduction in the failure of the food supply in the immediate vicinity of growth. That is, beginning with a well-nourished mycelium a diminution of food supply, other conditions being constant, usually compels reproduction. A change in the specific chemical content may be effective, and in other cases there are other concurrent stimuli. In the study of phanerogams it would seem that the problem is one which is, as a rule, far more complex. It has, however, been found possible with a few species to produce at will continuous vegetative growth or continuous flowering, to induce fruiting in a well-nourished vegetative shoot, and to incite vegetative growth in a flowering axis. It is probable that all shades of difference will be found in the capability of plants to have these processes distinguished by releasing stimuli; and it remains for the future to determine to what extent this is possible.

ENGINEERING NOTES.

It is generally figured that about 30 per cent of the total quantity of gas generated by the blast furnace is required for heating the blast, although this quantity varies considerably according to the quality of the gas, the design and construction of the hot-blast stoves and according to the conditions of operation of the blast furnace plant in general. For European blast furnace plants, the figure of 45 per cent is found frequently in reports endeavoring to determine the available power from blast plants, while in this country the gas necessary for the stoves is estimated in certain instances to be as low as 20 per cent of the total quantity produced.

An interesting marine record was recently established by the arrival of the British steamship "Goldmouth" at Rotterdam after steaming from Singapore by the route round the Cape of Good Hope, a distance of 11,791 miles, in 52 days. During the whole passage the engines worked at full speed and were not stopped once after leaving port until the destination was gained, nor was the generation of steam in the main boilers in any way checked during the period. This is believed to be the longest non-stop run ever made by marine machinery. Liquid fuel exclusively was consumed, and with such economy that upon arrival at Rotterdam there were still sufficient supplies left to carry the vessel through twenty days' steaming on her return voyage to the East.

To provide the care necessary for the large locomotive has involved the expenditure of large sums for adequate terminals. Facilities for quick and frequent washing of boilers became imperative. Better drop pits, and more of them, were necessary. Engine houses with heating plants that would heat, and smoke jacks that would ventilate, were required. The lighting of the house at night to provide for a continuous operation of the plant, on an efficient basis, was a recognized improvement. All this has been accomplished, and today we can be congratulated on having reached a plane of excellence, both in the design of the locomotive and in maintenance facilities, whereby the larger locomotive is being handled just as expeditiously as the smaller one was, a few years ago.

The British consul at Reykjavik in his last annual report draws attention to the rapid development of the gasoline motor for the propulsion of the Icelandic fishing boats, and the openings that exist for various manufacturers in this direction. During the past year the majority of these motor equipments and boats came from Denmark, the manufacturers of which have established a firm hold in the island, though a large proportion were also constructed by native firms. Most of the boats are open, but there is a demand for the decked type, which is necessary for deep-sea fisheries. The experience of the motor boats is highly satisfactory, the catches therewith being greater than with the ordinary craft. An idea of the extent of this development may be gathered from the fact that at Seydisfjord and Reykjavik an insurance business for power fishing boats has been established.

According to a recent report, a new 30-foot 10-inch motor boat, driven by a 15-horse-power engine, made a very creditable speed trial on Chesapeake Bay, near Oxford, Md. The hull was carefully designed, but was not finished for speed, in the usual manner, of hard wood or with a special coating of anti-friction material. The engine was a 15-horse-power, 3-cylinder Fairbank motor, and at the highest speed developed, the revolutions reached 850 per minute. Three miles were cov-

ered in very close to nine minutes, the last mile being made in two minutes and fifty-five seconds. At this speed the little craft rested upon the water as level and solid as though without motion, and the formation of the bow wave attested the fineness of her lines. Further, there was no dead water at the stern, and this fact indicated that the propeller was working at highest efficiency. It is declared that when fully tuned up, the boat will exceed twenty-two miles an hour. If the figures given for this trial are correct, the record for motor boats of this class has been broken, as the best speed so far attained by a 31-foot launch is 19½ miles per hour.

TRADE NOTES AND FORMULÆ.

Process for Rendering Ethers, Alcohols, Benzines, and Collodions Incombustible, by adding to the liquid carbon tetrachloride in suitable proportions. This is a slightly volatile body, which is dissolved cold in ethers, alcohols, and other products. The proportions are variable. For benzine, as an example, absolute incombustibility is said to be secured with 25 or 30 per cent of the tetrachloride. The result of numerous experiments shows that ignited benzine is extinguished if carbon tetrachloride is poured on the flames. It acts by solution in the benzine, and there is, therefore, the possibility of using the tetrachloride as an extinguisher of fire. For this purpose it may either be inclosed in grenades of thin glass to be thrown on the fire, or be directly projected by means of a pump. This is the Decrut method.

Insecticide for Vines.—The methods hitherto generally employed for the destruction and extermination of the phylloxera do not entirely accomplish the desired purpose. The Bertz method, patented in France, is claimed to secure the extermination in mass of these harmful insects. It consists of the use of a powder, the composition of which is as follows: 100 parts of caustic lime, 50 calcium chloride, 20 kitchen salt, 20 magnesium, 10 oxide of iron, 50 perphosphate, 30 pulverized wood charcoal, 10 sulphur, 15 kainite, 100 Thomas flour. These quantities are collected in the form of a very soluble powder.

To make use of the powder, one part by weight is dissolved in 10 parts of water, and the vines are sprinkled, so that it may be taken up, particularly by the roots. The phylloxera, as well as other insects which damage the vine, are, it is said, exterminated radically in a few hours by this treatment. The powder thus composed is also a good fertilizer for the plants.

Treatment of Natural Ores.—By the Jooss process, introduced in France, saline derivatives of alumina are obtained from complex silicates of alumina, which are said to be of remarkable purity so far as iron is concerned. As an example, silicates of magnesia and of alumina are cited. The following is an analysis of certain talcs: silica 45.5 per cent, alumina 26.5; iron, traces; lime 0.3, magnesia 18.5; loss, 8.9 per cent.

The preparation of the sulphate of alumina is accomplished by treatment with a sulphuric acid such that its concentration permits the elevation of temperature without inconvenience to 125 deg. to 130 deg. C., so as to render directly insoluble almost the whole of the silica which would otherwise be in the solution. Successive extractions are conducted according to known processes. Thus, a solution of sulphate of alumina and of magnesia, holding in solution a small quantity of sulphate of lime, is obtained. This is decanted, and the sulphate of magnesia separated from that of alumina by any known process; for example, by crystallization. It is evident that any other acid may be employed which will attack the complex silicates of alumina. The proportions to be employed are those indicated by the richness of the acid and the aluminous ore.

Manufacture of Hydrate of Baryta and Its Compounds.—Hydrate of baryta and of strontium are employed in the production of sugar, in which the saccharates are materially decomposed by carbonic acid. Various processes for the production of hydrate of baryta are in use, of which the simplest and the one of highest yield is founded on the treatment of barium carbonate. The carbonate is prepared by a treatment of crude barium sulphide and calcined carbonate of soda. The barium sulphide is obtained by reduction of the sulphate of baryta by means of charcoal. The solution of this sulphide, mixed with a solution of carbonate of soda, determines by double decomposition the precipitation of the barytic carbonate, which is separated by decantation, washed, and passed through the filter press. The pressed carbonate is converted into oxide by calcination and simultaneous treatment with superheated steam. The baryta obtained is washed and separated from the carbonate of baryta, not decomposed, and it is returned to calcination. The solution of baryta is submitted to crystallization. This process is preferable to that founded on the employment of saltpeter and metallic oxides.

The lyes of sodium sulphide may be utilized in different ways. One of these consists in concentrating the solution to 28 deg. or 30 deg. Baumé and leaving to crystallization. The product is sold to tanneries or factories of chemical products, or else the lye is utilized in the production of zinc sulphide. The sulphide is prepared by mingling a solution of zinc chloride with the sodium sulphide lye, washing the precipitate, and passing it through the filter press; it is slightly calcined. This is a product irreproachable in whiteness, and fineness is secured. It is pulverized and mixed with variable quantities of sulphate of baryta, and thus good commercial lithopones are obtained.—Farben Zeitung.

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